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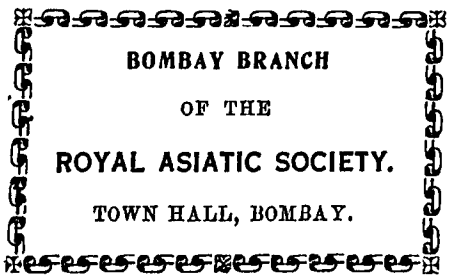

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REPORT

ON THE

ADMINISTRATION

OF THE

METEOROLOGICAL DEPARTMENT

OF THE

GOVERNMENT OF INDIA

IN

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REPORT ON THE ADMINISTRATION OF THE METEOROLOGICAL DEPARTMENT OF THE GOVERNMENT OF INDIA IN 1921-22.

CHIEF FEATURES OF THE YEAR.

1. The efficiency of a scientific department is so completely dependent on the maintenance of a trained staff that the loss during 1921-22 of two officers in addition to the two of whom we were deprived in the previous year has been the most important fact in the history of the year ; and both officers, Mr. W. A. Harwood and Mr. T. K. Chinmayanandam, resigned on account of dissatisfaction with the pay and prospects of the department. Mr. Harwood was offered and accepted a post under the English Meteorological Office, and is greatly missed in the upper-air observatory at Agra. He had there done several years of active and valuable work ; and he was relied upon in connection with the increased activities of the observatory which, it had been confidently hoped, would have been possible after the conclusion of peace. Mr. Chinmayanandam was one of the most promising of the younger physicists of India ; but after some two years' service in training at Simla and as Director of the Bombay observatory he has reverted to the Accounts Department.

Mr. Harwood's vacancy was filled by Mr. Chatterjee of the Presidency College, Calcutta, and Mr. Chinmayanandam's by Dr. S. K. Banerji of the College of Science, Calcutta. To one of the vacancies of 1920 in the Simla office Mr. Sohoni of the Wilson College, Bombay, was appointed in March 1922 ; but the other vacancy is still unfilled. None of the newly appointed men had a technical knowledge of meteorology and it has been with very great difficulty that the routine work of the department has been carried on.

Fortunately however some progress in research work was rendered possible by the presence in the Simla office for some months of three workers not connected with the department : for their benefit weekly ' colloquia ' were held at which papers were read and discussed. Mr. J. C. Kameswara Rav, M.Sc., a research student from the Calcutta University, made a careful analysis of all the cold weather storms for the past twenty years and thus appreciably advanced the preparation of type maps for daily forecasting : Mr. C. Seshachar, M.A., in training for service in the Mysore State, investigated the evidence from the lakes of the Tata electric power company regarding the influence of forests and lakes on rainfall : and Mr. P. C. Mahalaonbis, a Calcutta Professor, critically examined by statistical methods some important European work on the inter-relations between pressure and temperature in the upper air. The methods of forecasting for the winter rains and for the monsoon have also been advanced a stage further : early in the year investigations on the monsoon of the Peninsula during the past 45 years led to a formula based on only three factors which predicts over two-thirds of the variations of the rainfall, as compared with a half, which was given by the formula of 1908 : formulæ for other parts of India were also obtained. A more recent examination of conditions at the centres of action which largely control

weather over the earth has brought to light further relations ; but very much work has yet to be carried out before a reliable detailed forecast can be produced.

Mention should also be made of an investigation by Mr. Field now completed at Agra. For the exposure of thermometers the department has always used large open-sided sheds to prevent the sun's rays and the radiation from the heated ground from affecting the instruments. These sheds are said to have cost formerly less than Rs. 200 but now are priced at about Rs. 800 ; and the employment of some different device for efficiently shading thermometers is therefore desirable. Experiments with other types of shed and with various louvred Stevenson screens have been in progress at Agra for the past two years and their characteristics are now known for use in India. As a result, Stevenson screens are to replace all sheds in India as opportunity offers, and as the new screens will cost only about Rs. 50 each, their use will result in saving annually about Rs. 9,000.

The scientific side of the upper air work begun in Agra in 1914 was hampered greatly during the war by the absence of officers on field service. This year however a real advance has been made in the discussion of results. From the pilot balloon observations which tell the velocity and direction of the upper winds we have gained a clearer conception of the general circulation over India in the two monsoons ; the instrument balloons which have been sent up to record the air temperature, pressure and humidity as they ascend, though not very numerous, have been sufficient to disclose the approximate values of these elements in the different seasons at all heights up to 35,000 feet. Memoirs giving all the available data of winds at various heights have been published for the use of aviators, and discussions of the other data on these subjects are ready for publication.

Upper air stations were started at Quetta and Peshawar to serve the needs of military aviators flying on the frontier. Similar observations were resumed at Calcutta and Akyab, and were continued at Agra, Lahore, Simla and Bangalore. Upper air measurements from all these stations except Bangalore are available every morning at Simla for use in preparing a daily telegram for aviators in north-west India and in forecasting the weather generally.

Mention was made last year of the increase in responsibilities of the department in relation to upper air work for the Royal Air Force. A further demand for similar information has been arising in connection with Artillery practice camps, and by way of trial three of these have been attended in the past by balloon parties from Agra. It is understood that as a result of the usefulness of the work done in these camps the demand in the coming year will be increased, and Agra has been provisionally asked to make arrangements to send balloon parties to eight camps ranging in site from Belgaum to Quetta. With the present staff it will not be possible to meet the whole of this demand.

The warnings for ports and shipping in the Bay of Bengal and the Arabian Sea were on the whole carried out successfully. In the light of the fuller information subsequently available from logs of ships, which enable us to test the inferences made at the time from the coast observations, we find that of the seven storms which formed, the warnings for four were correct ;

for the other three the warnings, though less accurate, gave a correct interpretation of the information at our disposal. It is unfortunate that ships in stormy weather very seldom realise that information transmitted to us would be of the greatest value to other ships by improving the reliability of our storm service.

The warnings issued during the year, chiefly to irrigation and railway officers, for heavy rain likely to cause floods were the occasion of appreciative reports. In addition telegrams were sent to three military authorities in connection with the operations in Waziristan ; and of these the General Officer Commanding said ' throughout the operations of 1920-21 and the Wana Column operations these wires have been of the greatest value.'

Owing to the stringency of the financial situation no progress has been made in the project of transferring the work of the Colaba observatory and of the Bombay Meteorological Office to a single combined institution at Juhu, where the Bombay aerodrome was to be established. Two other building projects have been prepared and have received administrative approval, one for a new engine house at Agra and the other for a new wing to the Simla office, which has at present no workshop and quite insufficient library accommodation.

The chart at the end of the report illustrates the general changes in activity and in budget provision for the year.

Changes in the staff during the year.

2. Mr. W. A. Harwood, M.Sc., resigned his appointment, and Mr. T. K. Chinmayanandam, M.A., reverted to the Finance Department, during the year.

Mr. G. Chatterjee, M.Sc., and Mr. V. V. Sohoni, B.A., B.Sc., joined the department and were appointed Meteorologists, being posted to Agra and Simla respectively.

Mr. P. N. Mitra, Meteorologist, Bombay, made over charge to Mr. W. A. V. D'Rozario on the forenoon of the 1st April 1921.

Dr. Savoor took over charge of the post of Meteorologist, Madras, from Mr. Barnes from the 4th May 1921.

The system of storm warning.

3. The work of warning Indian ports of the approach of cyclonic storms or of bad weather is performed from the Simla office by the Director-General of Observatories, and from the Calcutta office by the Meteorologist, Calcutta.

Thirtytwo ports are warned from Simla for storms in the Arabian Sea. Fortyone ports and nineteen River Police stations were on the list at the beginning of the year for warnings from Calcutta for storms in the Bay of Bengal ; but of these Table Island and seven River Police stations were subsequently discontinued. In addition to these special messages sent during stormy weather the Meteorologist, Calcutta, provides shipping at thirteen ports, with daily information regarding the weather over the Bay under a special system of "additional" signals. Shipping at sea is also supplied with the latest information regarding the weather by means of wireless bulletins, which are trans-

mitted twice daily from the radio stations at Bombay, Karachi, Calcutta, Rangoon, Madras, Port Blair, Matara, Ceylon and Aden. The weather bulletins from Matara and Aden were started in March 1920 at the request of the Admiralty. A complete account of the warning system may be found in the "Code of Storm Warning Signals for use at Indian Ports", obtainable from the Superintendent of Government Printing, India, at Calcutta.

Warnings for storms in the Bay of Bengal.

4. During the year warnings were issued for nineteen disturbances, but none of them was classed as "severe". During six of them (21st-30th July, 31st August-4th September, 5th-8th October, 24th-27th October, 7th-9th November and 27th-30th December) winds at sea reached gale force; the first and fifth were storms of moderate intensity and others of only slight intensity. The warnings were correct and complete except that in the fourth storm on the 25th October the depression was located in the south-west instead of the centre of the Bay and that during the moderate storm of the 7th to 9th November a careless barometer reading from Diamond Island led to an inaccuracy in fixing the position of the storm centre on the morning of the 7th: this error was brought to light and corrected ten hours later. In addition to the nineteen disturbances mentioned above there was a disturbance between the 7th and 9th April which moved from the southwest of the Bay and disappeared off the north Madras coast: although winds reached gale force in this on one day it did not develop into a cyclonic storm, was difficult to detect from the land observations and passed unnoticed: so far as is known no loss resulted.

Warnings for storms in the Arabian Sea during the year.

5. The Simla office warns the west coast ports not only for storms, but also for squally weather, especially at the beginning of the monsoon. There were nine periods of disturbed weather in the Arabian Sea for which warnings were issued; and only one of these disturbances, that of October 9th-13th, developed into a cyclonic storm. This originated in the Bay where it was so small that, although it had a core with hurricane winds, it was hardly felt at a distance of 60 miles from the centre; and no indications were given at the coast stations of its severity. It crossed the Peninsula with quite unusual rapidity and developed into a severe storm in the Arabian Sea at once instead of in one or two days. In the absence of all wireless information from ships which had experienced its violence it was inevitable that this should be greatly under-estimated; so the warnings were not hoisted early enough and were lowered too soon, and shipping and ports were warned for the existence of a depression only, instead of for a severe but small storm.

Flood Warning and Weather Forecasts to District, Irrigation, Railway and other officers.

6. This work is carried out chiefly by the Simla Meteorological Office, and partly by that of Calcutta. The arrangements have been made at various times and differ considerably in character, according to the nature and extent of the flood or weather warnings required by the officers concerned. In most cases

these officers require telegrams either warning them of advancing storms likely to give heavy rain, or informing them of the actual occurrence of heavy rainfall likely to give rise to severe floods which might injure railways or canal works ; and in other cases, they require warnings or forecasts of the weather for as long a period beforehand as possible.

The number of district officers and officers in the irrigation, railway and other departments to whom flood warnings, weather forecasts or intimations of the likelihood of rain during the dry season were sent from Simla amounted at the end of the year to 231. There were also 7 officers of the Telegraph Department who required warnings for strong winds.

In order to provide against serious loss of life and property in inland Bengal when a cyclone from the Bay has crossed the coast 461 officers were added to the list of those warned by the Meteorologist, Calcutta ; of these 40 are requested to hoist signals under Appendix D of the Code.

The number of special forecast and warning messages sent from Simla during the year was 2938 and from Calcutta 820. In addition to the telegrams from the Meteorological offices at Simla and Calcutta 884 telegrams of actual heavy rainfall were sent by observers direct to various officers.

Instructions were issued by the Government of India in 1898 that every officer to whom storm or flood warnings are issued should, in the month of January of each year or, in the case of military expeditions, at the close of the campaign, forward to the head of this department a brief return of the warnings received and should also report whether the warnings were satisfactory and whether any changes might be made to increase the usefulness of the warnings.

Reports on the ordinary storm and flood warnings for the calendar year 1921 were received from 41 officers. Of these 24 stated that the warnings were satisfactory, and the remaining 17 offered no remarks.

A comparison of the reports of floods and of heavy rain with information supplied to the various officers would appear to show that the system is working satisfactorily, and that most of the warnings issued were of value to the recipients. As illustrations the following extracts from reports may be of interest :—

The Executive Engineer, Rupar Division, Sirhind Canal, wrote :—

" They (the storm warnings) continue to be of interest and value to officers-in-charge of the Head-Works. These remarks apply equally to the telegraphic warnings and the daily weather reports ".

The Port Officer, Orissa Ports, False Point, stated that :—

" Telegrams were satisfactory and effective in giving timely warnings in almost every case, except a few which were hindered in transit ".

The Chief Engineer in Sind stated that :—

" The warnings were timely and satisfactory in every respect and no change in the system is wanted. I appreciate the care and regularity with which the warnings are issued by the Meteorological Department ".

The Sub-Divisional Officer, Dehri Sub-division, wrote :—

" These telegrams (of the 26th and 28th July 1921) were very useful and timely, warning for a very quick rising flood ".

Supply of Meteorological Information.

7. In addition to the meteorological information published by the department, special information was supplied to the Meteorological Departments of England, Australia and Egypt. Climatological information, at times involving special calculation, is also provided for sanitary and other officers of Government as well as for private firms who are willing to pay the expense necessarily incurred. The extent to which the department is utilised in this manner will be seen from the chart appended.

Medical Department.

As in previous years the department has supplied information in connection with cases of heat-stroke among British soldiers. As information was required whenever the wet bulb temperature rose above 75° and as most of our observatories recorded readings at 8 hours only, wet maximum thermometers were maintained at nine cantonments in north-west India and the readings were supplied daily to the local medical authorities from the middle of April until September. The readings were also telegraphed daily to Simla and transmitted immediately to Army Headquarters, Medical Branch.

Information to Aviators.

A general forecast for north-west India with a summary of the existing upper winds was telegraphed daily up to the 15th March 1922 to the Royal Air Force, Headquarters, who distributed the information to all squadrons concerned ; but in view of the financial stringency these daily telegrams were discontinued after the 15th March.

Warnings to the Military Authorities in Waziristan.

In response to a request for " early forecast by telegram whenever there is a likelihood of bad weather in Waziristan " warnings were sent to the General Officer Commanding Waziristan Force, Dera Ismail Khan, throughout the year, to the Officer Commanding, Wana Column, Jandola, till the 7th February 1922, and to the Army Headquarters, Kohat District, between the 5th January to the 8th March 1922. In asking for the continuance of these warnings to his address the General Officer Commanding the Waziristan Force remarked that " throughout the operations of 1920-21 and the Wana Column operations these wires have been of the greatest value ".

Upper Air Work.

8. An increase in the number of pilot balloon stations was made, repairing to some extent the disadvantages suffered in the previous year from the necessity of closing stations and parting with trained staff. Thus Calcutta and Akyab pilot balloon stations were reopened in May and August, while Quetta and Peshawar were started in June and September respectively.

The central observatory at Agra, besides exercising a close supervision over the current work of these outstations, was busy clearing up the war-time arrears in the computation of upper-air data.

A complete analysis of cloud observations made from 1914 to 1919, and also of observations with kites and sounding balloons made up to the year 1918 was undertaken, and three papers giving the results of this work were compiled for publication in the India Meteorological Memoirs.

A paper "On exposures of thermometers in India" was sent to press for publication in the Memoirs, and two papers were prepared by Professor P. C. Mahalanobis, on the seat of activity in the upper-air and on the effect of errors of observation on upper-air relationships.

Researches by the Simla Staff.

9. Shortness of staff prevented any of the gazetted officers from carrying on systematically the preparation of type maps for daily forecasting, a matter of paramount importance.

Statistical work for investigating the relation of pressure at centres of action with the monsoon rainfall of the Peninsula was undertaken, and a formula was obtained which would enable the department to make a forecast in February with a correlation co-efficient nearly as high as that obtained with the old formula for the June forecast. For the forecast in June a formula was found which gave a correlation co-efficient of 0.8, *i.e.*, which should give indications regarding 80 per cent. of the variations of rainfall. The investigation was extended to the monsoon rainfall of north-west India also, but with less success.

Observatories.

10. The Directors of the solar physics observatory at Kodaikanal and of the magnetic observatory near Bombay publish separate annual reports to which reference may be made for accounts of their work.

The purely meteorological observatories under the department's care number 281, and include stations as far afield as Tehran, Kashgar, Aden and Seychelles. Their classification according to the frequency of the times of observation and to the number of elements observed was described in the 1918-19 report. While the maintenance of these observatories, the supply to them of tested instruments, and the careful scrutiny of their observations to detect mistakes naturally entail much work at headquarters, it seems unnecessary to deal with it in detail on account of its routine character. The correctness of observations depends upon the continuance of good exposure and condition of instruments at observatories, and upon the accuracy of reading by observers. The former point can only be secured by inspection visits of trained officers, but the latter can to some extent be estimated at headquarters from the data received. A judgment on the standard of accuracy maintained in reading the instruments may be gathered from the number of mistakes detected in the data for the Indian Daily Weather Report. The stations of great reliability, in which at most one mistake has been detected, numbered 12, while the number at which more than 50 mistakes were made was 9.

Inspection of Observatories.

11. This essential requirement for the maintenance of accuracy in results suffered again as a result of the continued shortness of staff, and during the last seven years the amount of inspection has fallen to about a third of the pre-war standard, the work having to be left mainly to the single Inspector of Observatories, Mr. P. K. Ghose. This officer inspected 35 observatories during the year, Mr. G. Chatterjee 3, while the Director-General of Observatories made inspections at Alipore, Agra, Bombay and Madras.

It was stated last year that it would be necessary to arrange for more frequent inspections in future, if reliance were to be placed upon the data of observatories, and with the recent appointments to vacant gazetted posts this should soon be possible.

Marine Meteorology.

12. The want of weather telegrams from ships at sea has always formed a difficulty in the determination of the movement and intensity of storms ; inferences had to be made from the coast observations only. To arrive at correct conclusions about storms in the Arabian Sea was especially difficult, as their movements had generally to be inferred solely from the observations received from the west coast of India, where moreover the Western Ghats have a disturbing effect upon the wind directions. Accordingly a system was organized in 1914 for collecting weather observations from ships by wireless telegraphy ; but shortly after its introduction it had to be stopped on account of the war and it could not be resumed until 1920. The Marconi Company were asked whether they would allow weather messages to be transmitted free of ships' charges, a concession allowed to one or two other countries and they agreed to this proposal, which took effect from the 1st July 1921. The system worked fairly well during the year, and the messages received during disturbed weather, though few, were very useful in determining the movement and intensity of storms.

The number of wireless weather messages from ships received at Simla during the year was 649. The thanks of the Department are due to the Commanders of vessels sailing in Indian waters for co-operating with it in this matter.

At Calcutta and Bombay a clerk at each port spends his whole time in visiting ships, making in each case a copy of the log and a comparison of the ship's barometer with a secondary standard, for the purpose of applying the necessary corrections to the readings in the logs ; and, after the barometer comparisons have been made, a statement of the error of the ship's barometer is given to the captain, in case he should desire to make use of it. The number of ships visited is materially less than that of the vessels which come into port, but it is ample for the purposes of the department.

The data thus obtained are utilised in the preparation of charts of disturbances in the Bay of Bengal and the Arabian Sea for future reference in connection with the storm warning work of the department, and in drawing up an account of the storms of the year for publication in the Annual Summary.

The arrangement made with Royal Alfred Observatory at Mauritius, for collecting marine data from the Indian Ocean, has been continued, and the thanks of this department are again due to that office for thus supplying a large amount of useful data.

Snowfall Registration in the mountain districts to the north and west of India.

13. The information as to the amount, distribution and time of occurrence of the snowfall in the Himalayan and Afghan mountain areas was on the whole tolerably complete, and the thanks of the department are again due to the various officers who have collected and forwarded it.

Rainfall Registration.

14. The registration of rainfall in India has invariably been carried out by the provincial authorities. In 1889 a uniform system was introduced by the Government of India, and the Director-General of Observatories was made consulting officer in connection with this work. His advice is sought regarding the starting of new raingauge stations, and he receives annual reports from the local officers responsible for the registration of rainfall upon the efficiency of the work. A general account of the system, which came into operation in the year 1891-92, will be found on pages 5—8 of the Administration Report of the year 1889-90, and on pages 6 and 7 of the Administration Report for the year 1890-91.

The following is a statement of the number of rainguage stations from which data were received for publication in the Rainfall data of India at the end of the year :—

Province.	Number of stations.	Province.	Number of stations.
Burma	231	Baluchistan	84
Assam	126	Rajputana	176
Bengal	244	Central India	118
Bihar and Orissa	312	Central Provinces and Berar...	189
United Provinces	276	Bombay and Sind ...	289
Punjab	192	Hyderabad	19
Kashmir	38	Mysore	77
North-West Frontier Province	33	Madras (including Pudukkotai, Coorg, Travancore and Cochin).	524

[1] As stated in the last Administration Report a letter was addressed in January 1920 to most of the officers in charge of rainfall registration asking for more frequent inspections of raingauges ; it was suggested that they should

adopt the method in vogue in the Madras Presidency of informing the district officers in January each year of the names of the stations which had not been inspected till then and of asking them to inspect as many of these as possible before the 31st March. The reports for 1920-21 showed a gratifying response to this letter. This year's reports exhibit a further improvement in the number of stations inspected in Bengal, Bihar and Orissa, Kashmir and Hyderabad. The percentage of inspections attained last year was maintained in all the other provinces with the single exception of the United Provinces; where however the number of stations inspected this year was only two-thirds of that last year.

The following reports give a brief summary of the reports of the officers in charge of registration for the year 1921-22.

Burma.—There were 230 raingauge stations against 216 last year; nine new stations were opened in the poorly represented Northern Shan States. Of the total 18 were meteorological observatories, 26 were in charge of the Public Works Department and 2 in charge of the Agricultural Department; the rest were under district officers. The total number of raingauges inspected during the year was 178, and the inspections were satisfactory: of the stations inspected 144 were reported to be in good, the rest in fair condition.

Assam.—The number of stations inspected was 114 and the number of inspections 160; the corresponding figures last year were 117 and 173.

Bengal.—The number of stations inspected was 151 as against 114 the previous year and 78 in 1919-20. The number uninspected was 94.

Bihar and Orissa.—The Director of Agriculture states:

> "It is satisfactory to note that out of 285 stations 242 stations were inspected by Gazetted officers against 210 inspected last year. The number of inspections increased in most districts, but in Patna only 5 out of 17 gauges were inspected. Steps were taken to remove the defects disclosed by the inspection cards.
>
> Registration was neglected or inaccurately carried out at several stations in charge, for the most part, of minor police and post office officials. It is difficult to bring effective pressure on such agents in connection with a duty in which they have no interest whatever and the value of the statistics could probably be improved considerably by abandoning the registration at stations where the officer responsible proves incompetent, and having the fact recorded in his character roll."

United Provinces.—Out of 272 stations under the supervision of district and canal officers, only 43 per cent. were inspected, as compared with 67 per cent. in 1920-21.

Punjab.—115 stations were inspected by civil officers once or twice in the year. The gauges in charge of civil officers were all in good condition. No report regarding the number of gauges inspected was received from the Hoshiarpur District. The raingauges under canal officers were also reported to be in good order.

Kashmir.—The Meteorological Reporter states "Out of 39 stations, 8 are meteorological observatories and the remaining 31 are merely rain recording

stations. The number of inspections of raingauge stations made during the year was 14 against 8 of last year, which is satisfactory ".

The North-West Frontier Province.—The Revenue Commissioner writes that out of 36 gauges 28 were inspected during the year excluding two which were destroyed by enemy action during the Afghan War. A paragraph devoted to the subject in the Annual Report of Land Records and Agriculture for 1920-21 states :—" The remarks made in last year's report as to the necessity for inspecting at least 75 per cent. of the raingauge stations each year have been complied with, as all the raingauges in the province with the exception of a few were inspected by collectors and their assistants during the year under report ".

Baluchistan.—The Revenue Commissioner does not give the number of stations inspected, but writes " Raingauges in the Agency were regularly read by persons in charge and inspected occasionally by various officers ".

Bombay and Sind.—The Director of Agriculture writes :—

" It is very satisfactory to note that the work of inspection has been more satisfactory even than in the previous year in the case of the British districts. Out of a total of 278 gauges in the Presidency as many as 241 or nearly 87 per cent. were inspected during the year under report as against 226 or 82 per cent. during the last year. The total amount of inspection also shows an advance over the previous year, the total number of inspections during the year being 354 against 334 of the last year."

" With regard to the Native States it may be said that though the progress made in the last year has not been maintained during the year under report, the amount of inspection is in no way unsatisfactory. Out of a total of 61 gauges as many as 44 have been inspected or 72 per cent. It is hoped to make a decided improvement, by repeated reminders during the course of the current year."

Rajputana.—The triennial report from the Agent to the Governor General, Rajputana, shows that during the three years ending 31st March 1922, all the raingauge stations were inspected in all the states except Marwar and Jaipur ; in the former only 15 stations were inspected out of a total of 31 and in the latter 36 out of 49.

Central Provinces and Berar.—The number of inspections of raingauge stations in the Central Provinces during the year was 206 against 202 in the previous year and 179 in 1919-20. In Berar there were 64 inspections against 88 in the previous year. It is stated that the inspecting officers of the 11 districts (Saugor, Jubbulpore, Seoni, Narsinghpur, Hoshangabad, Betul, Chhindwara, Nagpur, Raipur, Amraoti and Yeotmal) had not made sufficient inspections in conformity with instructions contained in paragraph 10 of Revenue Book Circular III-2.

Hyderabad.—There are 17 raingauge stations under the Nizam's Public Works Department, of which 15 were inspected. In addition there is a raingauge in charge of the Residency Surgeon and one at Bolarum attached to the Indian Station Hospital.

Mysore.—Out of a total of 226 stations in the state 184 or 81 per cent. were inspected against 80 in 1920 ; 106 gauges were visited more than once.

Madras.—Out of the 492 rain recording stations 394 were in the Madras Presidency ; of these 361 or 92 per cent. were inspected. Of the 100 stations in the States 95 were inspected as against 82 last year. The Meteorologist, Madras, desires greater promptitude in the despatch of inspection reports, and with a view to economy in postage the invariable use of the inspection report cards instead of letters.

Summary.

In Burma, Assam, Bihar and Orissa, the North-West Frontier Province, the Bombay Presidency, Hyderabad, Mysore and Madras, the proportion of rainfall stations inspected was over 75 per cent., which is satisfactory. In Bengal, the Punjab, and the Central Provinces, where between 50 and 75 per cent. of gauges were inspected, there is room for further improvement. But in the United Provinces and Kashmir, where less than 50 per cent. of stations were inspected, serious efforts should be made to increase the percentage of inspections.

Seismograph Observations.

15. Seismological observations were recorded throughout the year by two Omori-Ewing seismographs at Simla and at Calcutta and one at Bombay ; by Milne seismographs at Kodaikanal ; and by means of other self-registering instruments at Colaba (Bombay). The data were transmitted to the Seismological Committee of the British Association.

Time signals.

16. The observatories at Madras, Calcutta and Bombay determine time from star observations and communicate it to the local ports by time-ball signals. The distribution of time over the country generally is made from the Madras observatory by a signal transmitted daily at about 16 hours over the Indian telegraph system. A wireless time signal for the use of ships broadcasted twice daily at 1-30 and 13-30 G. M. T. from the Calcutta Radio station ; the signal is sent direct from the Alipore observatory by automatic apparatus. At Bombay the Telegraph Department have completed the line from the Colaba observatory to the Radio station, but the automatic apparatus for transmitting the signals has not yet been installed.

All the time work was performed satisfactorily during the year.

Publications.

17. There were no changes made, during the year in the form of the routine publications of the department, of which a description will be found in the departmental administration reports of 1907-08 and 1910-11. Publication of the Monthly Weather Review and of the Annual Summary, which had been stopped during the war, was actively resumed, and the issue for December 1918 had appeared by the end of the year.

The monthly and annual supplements to the Indian Daily Weather Report have been printed as usual, and supply the general need for prompt information.

As usual, the telegraphic weather summary was despatched to subscribers daily about noon and the weekly rainfall summary was supplied to the *Gazette of India* and to press correspondents in Simla.

The amounts realised from subscribers during the year for the daily telegraphic weather summary was Rs. 5,023, while those received for the Indian, Bengal, Bombay and Madras Daily Weather Reports and for Weekly Weather and Crop telegrams totalled Rs. 6,993.

The amount debited to this department by the Post and Telegraph Department for the transmission of the daily telegraphic weather summary throughout India is about Rs. 5,000 a year, and includes provision for a number of Government officials to whom it is supplied free.

The following memoirs of the Indian Meteorological Department were published during the year :—

Volume XXII, Part VI, 'On dust-raising winds and descending currents,' by Dr. E. H. Hankin.

Volume XXII, Part VII, 'On dust-raising winds, by Dr. C. W. B. Normand.

Volume XXIII, Part I, 'Wet bulb temperatures and the thermodynamics of the air,' by Dr. C. W. B. Normand.

Volume XXIII, Part II, 'Correlation in seasonal variations of weather, VII, The local distribution of monsoon rainfall,' by Dr. Gilbert T. Walker.

Library.

18. The number of books and pamphlets, either purchased or presented by scientific bodies added to the library during the year was 688 as against 598 in the year 1920-21.

The work of classification based on the schedule of the International Catalogue of Scientific Literature, made fair progress, the current books and pamphlets being classified on receipt and the cataloguing of the old stock in the library being gradually carried on. Both subject and author card catalogue are being prepared. By the 31st of March 1922, 4709 books and pamphlets had been catalogued and card indexed.

Concluding Remarks.

19. The Meteorological Department owes a large part of its usefulness to the sympathetic assistance it receives from outside departments. Civil Surgeons and other officers of Government departments, as unpaid superintendents of observatories and in other capacities, help in the meteorological work ; the Telegraph and Postal Departments assist in every way in the rapid transmission of meteorological information, at the same time that they allow their employés to act as observers. The Indo-European Telegraph Department, also, by giving free transit to the daily records of the Persian observatories, places a large

amount of most useful information at the disposal of the Meteorological Department. Weekly telegrams were received from May to September from the Director of the Royal Alfred Observatory, Mauritius, as well as from the departmental observatories at Zanzibar and Seychelles. These telegrams gave valuable information of the weather conditions in the Indian Ocean and the department is indebted to the officers indicated for the punctual transmission of the information. Thanks are more specially due to the Director of the Royal Alfred Observatory for his courtesy in placing the meteorological data of that observatory at the disposal of the Indian Meteorological Department.

The department is greatly indebted for important information about meteorological conditions prevailing before and during the south-west monsoon to the Controller, Physical Department, Cairo ; the Directors of the Observatories at Buenos Ayres, Santiago and Batavia ; and to the various officers around the Indian frontiers who have collected and supplied valuable snowfall information.

GILBERT T. WALKER,

Director-General of Observatories.

SIMLA ;

The 25th September 1922.

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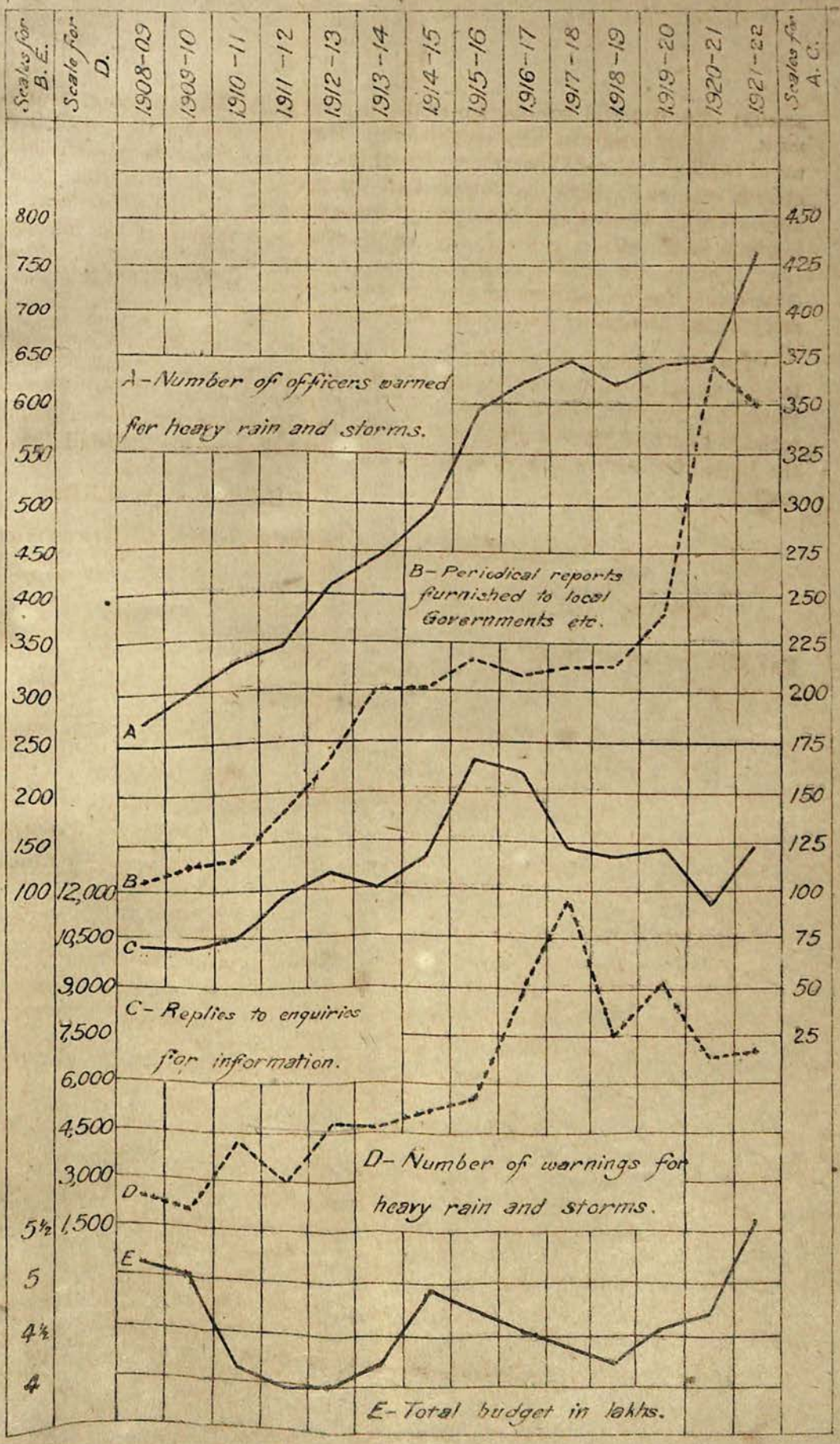
GROWTH IN ACTIVITY AND COST



REPORT

ON THE

ADMINISTRATION

OF THE

METEOROLOGICAL DEPARTMENT

OF THE

GOVERNMENT OF INDIA

IN

1922-23

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OF THE
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REPORT ON THE ADMINISTRATION OF THE METEOROLOGICAL DEPARTMENT OF THE GOVERNMENT OF INDIA IN 1922-23.

1. Chief features of the year.

The serious shortness of gazetted staff which has for some years crippled the activity of the department has been remedied in the course of the present year by recruitment of Indian science graduates for the various vacant posts, under the new time-scale pay sanctioned in December 1921 by the Secretary of State. With these improved conditions it had been hoped that when the newly appointed officers should have assimilated their meteorological training, it would be possible to tackle arrears of work such as the inspection of observatories, the production of revised editions of the Atlas of the Indian Seas, the Handbook of Storms in the Indian Seas, and the preparation of type maps of Indian weather, which would greatly help in improving the accuracy of the daily forecasts and warnings. But although many of these activities are now within reach, the most urgent of them all, inspection of observatories, has been deferred by the unexpected reduction, in the new budget for 1923-24, of the monetary allotment for travelling allowances. In these circumstances the position of the last five or six years must continue for the present, and adequate inspection by the more responsible officers cannot be undertaken either for routine observatories or for those specially used for cyclone warning at sea. At present the staff of officers as a whole have direct recent knowledge of only about 10 out of more than 250 observatories under charge of the department; and it has to be recognised that although all the vacant gazetted posts have been recently filled, the prospect of improvement in respect of inspections is still disappointing.

In these days of criticism that Indianisation in the services proceeds at too slow a rate, it is worth while to note what has happened in this department. The policy of Indianisation was definitely adopted over two years ago and the personnel occupying the thirteen posts of the grades of Meteorologist and Assistant Meteorologist, of which three are half-time appointments, has changed from 10 Europeans and 3 Indians in September 1919 to 3 Europeans and 10 Indians in March 1923. This change has not been helped forward by any retirement on proportionate pension, for that privilege has been denied to this department.

In the main observatories the staff has been considerably modified in the course of the year. Mr. Evershed retired on the 26th February 1923 from the directorship of Kodaikanal Observatory, a post which he had occupied with very conspicuous distinction for twelve years. His work on solar physics stands in the front rank of achievement, and has met with world-wide appreciation. For Bombay Observatory a new Director was appointed in April, and has been under training in Simla. Calcutta Observatory lost the services of Dr. E. P. Harrison, by his acceptance of a Home appointment under the Admiralty; and Agra Observatory lost its only remaining European officer, Mr. Field, who was transferred to Simla in March to tide over difficult times at headquarters during the leave first of Dr. Normand and then of Dr. Walker.

In the direction of research, a feature of this year has been the expedition under charge of Mr. Evershed from Kodaikanal to make photographic observations in Australia on the total eclipse of the sun. Interest in solar eclipses has in recent

years become world-wide in view of their importance in verifying the theory of Einstein; and it is a matter of congratulation that India should have been represented among the several expeditions engaged on this work.

The department has continued its determination of upper air movements, a knowledge of which is extending our facilities for interpreting weather changes, laying the foundation for types of forecasting not hitherto possible from surface observations, and preparing for the inevitably coming demand for the precise information necessary to safeguard aeroplane flying and minimise its cost. A feature of immediate public service has been evolved as a result of requests in 1920 and 1921 by the Military authorities for balloon parties to attend three artillery camps at which gun-calibration and practice were to be undertaken. The work of the Agra balloon parties was then found useful, and was followed this year by demands for some 8 or 9 similar parties to attend artillery camps ranging from Quetta to Belgaum. This point is further dealt with in paragraph 8 below.

On the loss of Dr. Harrison it became necessary to remove to Simla the duties of warning for cyclones in the Bay of Bengal, and for floods inland around the Bay, duties which from the earliest days of the department have been assigned to the Meteorological Office at Calcutta; and with this transfer completed, the whole system of warnings for storms and cyclones in both sea areas and on land throughout India now lies permanently with the Headquarters' Staff.

During the year these warnings, as issued, were on the whole satisfactory (but see paragraph 5) for the eight storms in the Bay and the two in the Arabian Sea.

In response to orders calling for retrenchments the department reduced its expenditure during the course of the year by Rs. 37,000 below the originally sanctioned budget allotment of Rs. 7·14 lakhs. Amongst the items of reduction mention may be made of the stoppage of publication of both the Bombay and Madras Daily Weather Reports from the 1st January 1923 to the end of the year under review. In future the issue of these reports, and of the Calcutta Daily Weather Report is to be restricted to 6 months, 9 months and 10½ months respectively, in the year, the periods of suspended publication being the seasons of least rainfall in the Presidencies. Further, the stations reporting to Calcutta have been reduced in number, and now represent only Assam, Bengal, and Bihar and Orissa; similar curtailment for the Madras Report was also decided upon. Other retrenchments were arranged for by the replacement of the Monthly Weather Review by a much briefer Monthly Weather Report, the abolition of the Assistant Director's post at Kodaikanal Observatory and by drastic restrictions in the free distribution lists of the various weather reports. Proposals were also submitted for the abolition of the half-time post of Meteorologist, Bombay, and the amalgamation of the Bombay Meteorological Office with the Colaba Observatory.

2. Leave and new Appointments.

Dr. Gilbert T. Walker proceeded on eight months' leave on average pay on the 8th February 1923. Mr. J. H. Field was appointed to officiate as Director-General of Observatories.

Mr. J. H. Field was on 26 days' leave on average salary (privilege leave) from the 21st September to the 16th October 1922 inclusive.

Dr. Normand returned from 8 months and 22 days' combined leave on the 12th December 1922.

Dr. S. K. Banerji joined the department on the 11th April 1922, was appointed Meteorologist, and posted to Bombay.

Dr. B. N. Banerji joined the department on the 11th January 1923, was appointed Meteorologist, and posted to Simla.

Mr. G. Chatterjee was granted leave on average pay for one month and 21 days from the 9th March 1923.

Mr. J. Evershed retired on superannuation pension from the 26th February 1923.

Dr. T. Royds was appointed Director, Kodaikanal and Madras Observatories, from the 26th February 1923 on his personal pay. The Assistant Director's post has been abolished as a measure of retrenchment.

Professor P. C. Mahalanobis took over officiating charge of the post of Meteorologist, Calcutta, from Dr. E. P. Harrison on the 7th November 1922.

Mr. S. Sitaramayya, B.A., was granted 28 months' leave from the 9th September 1922 preparatory to retirement. Mr. A. R. Malik, M.A., B.Sc., was appointed to act.

Mr. V. Doraiswamy Iyer, B.A., was appointed Assistant Director, Agra Upper Air Observatory from the 25th May 1922, but remained posted at Simla.

Rao Sahib V. V. Iyer took over charge of the post of Meteorologist, Bombay, on 1st March 1923 from Mr. W. A. V. D'Rozario : Mr. L. L. Rao took charge of the same post on 28th March 1923 from Rao Sahib V. V. Iyer.

3. The system of storm warning.

The work of warning the Arabian Sea ports of the approach of cyclonic storms or of bad weather was done throughout the year from Simla. The warnings for the Bay ports were, as in previous years, in charge of the Meteorologist, Calcutta, up to the 7th November 1922, but after that date this duty was permanently transferred to Simla, where all warning work of every description is now concentrated. This change is likely to be advantageous on public grounds, for it allows of collective consideration by two or more professional meteorologists of points of difficult interpretation during cyclones, when telegrams of the special observations called for have come in by night or day ; and it should be possible to reduce the errors of judgment which necessarily occurred from time to time when the duties lay entirely on the shoulders of a single half-time officer in Calcutta.

Thirty-two ports are warned for storms in the Arabian Sea, and forty ports and fourteen River Police Stations for storms in the Bay of Bengal. Of the Bay ports thirteen get additional information regarding the particular sections of the Bay in which weather is disturbed, a special system of 'locality signals,' being in use for this purpose. Shipping at sea is also supplied with the latest information regarding the weather by means of wireless bulletins, which are broadcasted twice daily from the radio stations at Bombay, Karachi, Calcutta, Rangoon, Madras, Port Blair Matara (Ceylon) and Aden. The weather bulletins from Matara and Aden were started in March 1920 at the request of the Admiralty. A complete account of the warning system may be found in the " Code of Storm Warning Signals for use at Indian Ports," obtainable from the Superintendent of Government Printing, India, at Calcutta.

4. WARNINGS FOR STORMS IN THE BAY OF BENGAL.

During the year warnings were issued for 27 periods of disturbed weather; the disturbances developed into slight or moderate storms during five of these periods, and into cyclones during three. Of the former storms two were of the usual monsoon type forming at the head of the Bay; one formed in the Gulf of Manaar and passing out into the Arabian Sea, intensified there into a moderate storm; one was of short duration and dissipated at sea and the fifth formed in the south of the Bay and crossed the Burma coast near Sandoway. The warnings were correct for all these storms. The three cyclones occurred in the periods 19th to 24th April, 8th to 10th November and 17th to 23rd November. During the April cyclone, which formed to the south-east of the Andamans and crossed the Chittagong coast near Cox's Bazar, the warnings were correct except towards the end when the intensity of the storm was under-estimated and the danger signal was not hoisted at Cox's Bazar. During the first cyclone of November which crossed over Akyab, the warnings contemplated its crossing to the north of that station; but danger signals were kept flying at all ports likely to be affected, including Akyab. In the case of the second cyclone of November, it was believed to be approaching the coast between Cocanada and Masulipatam much faster than it actually did, as very severe weather was experienced there even when it was well out at sea; the warnings to the ports were however correct.

5. WARNINGS FOR STORMS IN THE ARABIAN SEA DURING THE YEAR.

The Simla office warns the west coast ports not only for storms but also for squally weather, especially at the beginning of the monsoon. There were 12 periods of disturbed weather for which warnings were issued: during 10 of these the warnings were for squally weather or strong winds connected with the monsoon. In the remaining two periods the warnings were for a cyclone and a storm. For the first of these, which affected the south-east Arabian Sea from the 18th to the 22nd April, warnings were inadequate as the coast observations did not definitely indicate its existence during its earlier days, and such indications as appeared were not fully appreciated. The warnings for the second, in December, were correct, mainly through the great help received by wireless from ships' observations at sea, an advantage which had not been available in the earlier storm in April.

In regard to that earlier storm, it has been said above that warnings were inadequate for reasons given; but it should be added that the Principal Port Officer, Travancore, Alleppey, made certain strong criticisms of the warning action taken during the earlier stages of the storm, in so far as small coasting craft were concerned. Damage to such craft by squally weather was reported to the extent of Rs. 12,000, and the Port Officer held the view that this would have been averted had the warnings been suitable and timely.

An examination in the light of the information now available shows that the grounds for his criticism were not unreal; and while the main operations of the cyclone were properly dealt with, this failure during the early stages of its formation is an instance—fortunately small—of the serious consequences which may result from an inadequate staff provision at warning headquarters: it was a direct result of shortness of officers at the time. Vacant posts have since been filled with officers now to be trained, but with the recent amalgamation of all Indian cyclone warnings for both Arabian Sea and Bay of Bengal by transfer of the latter warnings to Simla, the staff is again below what is necessary to deal with these matters of potential disaster at sea and loss on land.

A further point which militates against the attainment of highest efficiency in cyclone warning duties is the fact that for many years past it has been impossible to spare a responsible officer from a deficient staff to tour the coast ports used in this warning service. The last occasion of such a tour was in 1915, and there has been for some years the need to redetermine instrument exposures known to have become bad, to fix new instruments in many places, and to change observing personnel where this has lost a full sense of responsibility or could be better replaced by local officers more directly connected with the ports concerned.

The duties of cyclone warning are so important that the department takes a serious view of the present position, where the costs of the needed additional staff are so incomparably smaller than the interests involved. The matter of staff is under consideration by Government, but it is understood that the present financial position renders difficult the provision desired.

6. Flood and Storm Warning, and Weather Forecasts to District, Irrigation, Railway and other Officers.

This work was done jointly by Simla and Calcutta Meteorological Offices up to the 7th November 1922, and entirely by the former after that date. The arrangements have been made at various times and differ considerably in character, according to the nature and extent of the flood or weather warnings required by the officers concerned. In most cases these officers require telegrams either warning them of advancing storms likely to give heavy rain, or informing them of the actual occurrence of heavy rainfall likely to give rise to severe floods which might injure railways or canal works; and in other cases, they require warnings or forecasts of the weather for as long a period beforehand as possible.

At the end of the year the number on our lists of district officers and officers in the irrigation, railway and other departments to whom flood warnings, weather forecasts or intimations of the likelihood of rain during the dry season were to be sent by this department was 188. There were also 20 officers of the Telegraph Department requiring warnings, mostly for strong winds.

In order to provide against serious loss of life and property in inland Bengal when a cyclone from the Bay crosses the coast, 461 officers were added during the previous year (1921-22) to the list of those to be warned in such cases, and with the transfer of all such duties to Simla the whole work is now under the charge of Headquarters. Of these officers 40 hoist the signals shown in Appendix D of the "Code of Storm Warning Signals" whenever warned to do so.

The number of special forecasts and warning messages issued by the Department during the year was 4,166, and in addition 825 telegrams of actual heavy rainfall were sent by meteorological observers direct to various officers.

Instructions were issued by the Government of India in 1898 that every officer to whom storm or flood warnings are sent should, in the month of January of each year or, in the case of military expeditions, at the close of the campaign, forward to the head of this department a brief return of the warnings received and should also report whether the warnings were satisfactory and whether any changes might be made to increase the usefulness of the warnings.

Reports on the storm and flood warnings for the calendar year 1922 were received from 51 officers. Of these 28 stated that the warnings were satisfactory, 18 gave no remarks, and the remaining 5 offered suggestions or criticism. Out of

these last named officers two, the Port Officers of Chittagong and Akyab proposed the transfer of the duties of taking meteorological observations to their charge on the ground that they could offer more knowledgeable help than the present observers, and would be able to telegraph voluntarily any important weather changes during the actual progress of storms. The suggestion conforms with the views of the department, and such changes will be brought about there and elsewhere when an opportunity arises for a responsible officer to visit the stations.

The Sub-Divisional Officer, Dehri Workshops Division, also made some suggestions regarding the improvement of warnings for his area.

On the whole a comparison of the warnings with the actual subsequent rainfall shows that the system is working satisfactorily, and that most of the warnings issued were of value to the recipients. As illustrations the following extracts from reports may be of interest : —

The Executive Engineer, Ambala Provincial Division, wrote : " the flood warnings were timely received and were satisfactory in every respect ".

The Superintending Engineer, Indus Left Bank Division, stated that " warnings conveyed by them (telegrams) were generally timely and met requirements."

The Chief Engineer, Indus River Commission, stated that " the warnings were timely and satisfactory in every respect and no change in the system is wanted. I appreciate the care and regularity with which the warnings are issued by the Meteorological Department."

Warnings to Military Authorities in Waziristan.

Telegraphic forecasts of the likelihood of bad weather were sent throughout the year to five different and changing centres in connection with the Waziristan field operations. Opinions as to the utility and possible improvement of the system were invited from responsible officers, and all of them recognized the forecasts as accurate and valuable. The General Officer Commanding, Waziristan Force, suggested that day-to-day forecasts should be sent as " Priority " messages and in response to this wish, warnings when they relate to the day on which they are issued, are now sent as " XXW-Storm " telegrams. The General Officer Commanding, Kohat District, as well as the Intelligence Bureau, Kohat District, says that occasionally the change of weather predicted in the warnings was experienced some hours before the time announced ; it is understood, however, that full value was obtained from these warnings in basing on them the movements of troops and animal convoys.

7. Supply of Meteorological Information.

From time to time special information was supplied to the meteorological departments of England, Australia and Egypt. Climatological and other data, at times involving special calculations, were also provided for sanitary and other officers of Government as well as for those private firms who were willing to pay for the service. The extent to which the department is utilized in this manner will be seen from the curves B and C in the graph at the end of this report.

8. Upper Air Work.

The Upper Air work centres round the observatory at Agra, which supplies material and equipment to the outstations spread over India and Burma, where

pilot balloons are sent up daily; and exercises close supervision over their work. Information on certain features of the upper air currents is telegraphed to Simla for use in daily forecasting.

The pilot balloons are made of guttapercha tissue about one thousandth of an inch in thickness. They are filled with hydrogen and released, carrying a tail of standard length (usually 100 metres), and are observed as long as possible through a theodolite, while regular timed readings are taken of their horizontal and vertical angles, and of the apparent lengths of their tails as seen in the theodolite. With these measurements the height, distance and geographical course of the balloon can be calculated.

A 6-foot balloon, ready to go up, is shown in figure 1 (on plate at the end), while figure 3 is a picture of a balloon-maker joining the guttapercha segments to form a finished balloon. Usually only 2-foot and 3-foot balloons are used.

Such balloons (3-foot) reach heights as great as 10 miles while still in sight in the theodolite telescope, and in clear weather may sometimes be kept in view up to total distances of nearly 60 miles, accurate measurements of wind velocity and direction being taken over the first 30 miles of their courses. At heights of 4 miles and upwards the cold weather winds of northern India often reach a strength of 100 miles per hour, and are occasionally stronger still, while calms prevail at the surface.

In former years a large number of trials were made with such balloons carrying small self-recording instruments known as meteorographs, of which figure 4 (plate at end) shows the Dines' type. Such an instrument registers accurately the pressure and temperature, and roughly the humidity, at all heights during its ascent and descent; it weighs just about an ounce and has sometimes in Europe reached heights as great as 15 miles. Steel marking points attached to the recording portions make indelible records on a silvered sheet of metal or glass, the whole record being about the size of a postage stamp, and requiring a micrometer microscope to decipher it. Before use these instruments have to be calibrated for pressure in special air-pump apparatus, and for low temperature (such as exists in the upper air) by immersing them in petrol, cooled with carbonic acid snow to about −60°C (108° of Fahrenheit frost).

On descent a meteorograph may land as far as a hundred miles, or even more, from the place at which it was sent up; and to secure its return, a label in several vernaculars is attached to each instrument-basket sent on a flight. The finders (of whom two are illustrated in figure 2) get a reward for delivering the basket to the District Officer in good condition. About 70 per cent. of such instruments are usually recovered.

Besides the work of computation of upper air data, the complete analysis of cloud observations, taken regularly several times a day at 11 stations in India, is also a routine business in Agra. Repair of instruments belonging to the department is undertaken at the workshop of the observatory.

An important feature of the year was the organization of a service of "meteor" parties for the artillery practice camps to which a reference has been made in paragraph 1 of this report. The requirements of the military authorities were met, but with some difficulty on account of inadequacy of observing staff at Agra: and

the step proves to have been fully warranted as judged by expressions of appreciation from Army Headquarters. It is understood, indeed, that the detailed numerical information on wind strengths and varying directions obtained by balloons several times daily during gun-practice is now considered indispensable; and the department has since been asked further to co-operate by devising some practical form of affiliation between Agra Observatory and Field Service organizations on war frontiers. It appears that it may become necessary to consider for the future some provision of extra trained staff for this work, if the scientific work of the Agra Observatory is not to be handicapped.

Among the contemplated activities at Agra may be mentioned the extension of pilot balloon work, the re-starting of meteorograph flights, night flights with ordinary balloons and a study of the temperature gradient above ground.

9. Researches by the Simla Staff.

Shortness of gazetted staff again prevented a start being made on the preparation of type maps for daily forecasting, which have for some years been regarded as an important requirement.

A paper by Dr. Walker on "A preliminary study of world weather", based on statistical study of weather changes in different parts of the world, was prepared for publication.

It has been discovered that the westerly components of upper air winds at Agra at a height of about 4 miles, as prevailing from the middle of September to the middle of October show a close relationship with the precipitation in north-west India in the winter following. This matter is being followed up in view of its probable high value, should it prove to be supported by a larger series of years of observation.

10. Observatories.

The Director of the Solar Physics Observatory at Kodaikanal published a report on astronomical work for 1922.

The Observatory takes a prominent part in the world-wide programme in hand by the International Astronomical Union. At a meeting in Rome in 1922 the Union allotted to India (Kodaikanal) the task of collecting from all contributing observatories in other countries the photographs of solar prominences and of the sun's disc taken in monochromatic (H 8) light, and of measuring them systematically. This work was begun regularly in January 1923.

The routine at Kodaikanal includes, among other things, taking and measuring photoheliograms and spectro-heliograms, and observations of sun-spots and prominences. Photos of two prominences—vast eruptions of glowing masses of vapour, rising from the sun's surface with velocities sometimes as great as 500 miles a second—may be seen in figs. 5 and 6 on the plate at the end of this report. Fig. 5 shows a typical prominence associated with a sun-spot and composed of hydrogen, helium, sodium, magnesium and iron. It was about 50,000 miles high, and lasted for more than 4 months, with continual variations in shape. Fig. 6 is another prominence composed of hydrogen, calcium and helium, and extending to a height of nearly 100,000 miles. At its first appearance it was a quarter of a million miles high, and its life was nearly 3 months. Measurements of prominences are possible only when they are on the limb of the sun, where they can appear repeatedly on account of the solar rotation.

Figs. 7 and 8 are photographs taken on 29th and 31st December 1922 showing sunspots appearing in different positions on the disc on account of the rotation of the sun in the intervening two days. The complete period of this rotation at the solar equator is 25 days, and 27½ days at 45° of solar latitude. The bright patches on these photos are regions where hot calcium vapour has been brought up from lower levels by a solar disturbance.

In the course of his study at Kodaikanal of the solar spectrum Mr. Evershed has found displacements of the spectrum lines of sodium and iron which are comparable in amount with what should occur, on the Einstein theory, as a result of the sun's gravitation: his work thus lends experimental support to the theory and prediction of this effect.

In regard to structural matters in the equipment of the Observatory the only development during the year was the replacement of the existing roof of the spectroheliograph building by a double roof for reducing the variation of temperature inside the building.

Colaba Observatory and Alibag Magnetic Observatory remained in good condition throughout the year. The more important of the scientific data which result from the work at these observatories will be found in the annual volume which is now to replace the old quinquennial volume of Bombay data.

At the Colaba Observatory an extensive routine activity is the rating of Royal Indian Marine and Royal Navy Chronometers, of which more than 200 were issued to ships, after rate-testing. In addition to its usual work this observatory will soon have the additional duty of issuing the Bombay Daily Weather Report, as the Bombay Meteorological Office is to be amalgamated with the Observatory.

The Madras Observatory supplies time, astronomically determined, to the whole of the country. Calcutta broadcasts time signals independently at certain hours of the day for ships at sea and in order to render possible an accurate comparison between the Calcutta and Madras clocks, a new wireless receiving apparatus was set up at the Madras Observatory.

The purely meteorological observatories under the department's care number 283 of which 237 were maintained by the Government of India; these include stations as far afield as Tehran, Kashgar, Aden and Seychelles. According to the classification given in the report for 1918-19, the departmental observatories consisted this year of 5 of the first class, 185 third class, 23 fourth class and 24 fifth class.

The maintenance of these observatories, the supply to them of tested instruments, and the careful scrutiny of their observations to detect mistakes, naturally entail much work of a routine character at headquarters. The correctness of observations depends upon the continuance of good exposure and good condition of instruments at observatories, and upon the accuracy of reading by observers. The former point can only be ensured by inspection visits of trained officers, but for many years this need has had to be neglected. The latter point can to some extent be estimated at headquarters from the data received. An idea of the standard of accuracy maintained in reading the instruments may be obtained from the number

of mistakes detected in the data for the Indian Daily Weather Report. The stations of great reliability in which no mistake or at most one has been detected, numbered 33, and the number at which more than 50 mistakes were made was 2. The average number of mistakes during the year at the remaining stations was 12.

11. Inspection of Observatories.

This essential requirement for the maintenance of accuracy in results suffered again, as in the previous seven years, from shortage of staff, but although towards the close of the year the complement of gazetted officers became full, an improvement in respect of inspection cannot be expected in the near future on account of the new restrictions in travelling grants (see paragraph 1). During the year, 24 stations were inspected by gazetted officers and others, while the Director-General of Observatories and the Officiating Director-General of Observatories made inspections at the principal observatories at Alipore, Madras, Bombay and Agra.

12. Marine Meteorology.

Wireless weather messages from ships at sea and the ships' logs to which access is obtained at the ports of Bombay and Calcutta are the main sources of marine data collected by the department.

The object of the system of radio messages from ships is mainly to supplement coast observations in cyclone warning work. In the absence of observations from the sea areas it was not always easy to draw correct conclusions about the position, movement and intensity of storms. This was the case particularly with disturbances in the Arabian Sea, for which inferences had in general to be drawn from the very insufficient observations from the western coast line of India. The system was organized in 1914, but with the outbreak of war it remained in abeyance till it was reopened in 1920; subsequently in July 1921 the Marconi Company agreed to help the department by allowing these telegrams to be transmitted free of ships charges. It worked fairly well during the year and messages from ships, not only those in the vicinity of the storm but also vessels at considerable distances from the centre, were found useful in determinations of position and course.

With the permanent transfer to Simla in November 1922, of the work of storm warning for the Bay of Bengal the number of W/T messages from ships received at Simla during the year rose to 956, and the thanks of the department for these are due to the commanders of ships, sailing in Indian waters. There is still much scope for improvement in the direction of fuller co-operation between ships and this department.

In regard to the second source of marine data, the work of visiting ships and copying logs at Calcutta and Bombay is entrusted to clerks from the local offices of the department. The number of ships visited was materially less than the arrivals, but was as large as an inadequate staff could deal with.

The data thus obtained are utilised in the preparation of charts of disturbances in the Bay of Bengal and the Arabian Sea, for future reference in connection with the storm warning work of the department, and in drawing up an account of the storms of the year for publication in the India Weather Review (Annual Summary).

13. Snowfall Registration in the mountain districts to the north and west of India.

The information as to the amount, distribution and time of occurrence of the snowfall in the Himalayan and Afghan mountain areas was on the whole tolerably complete, and the thanks of the department are again due to the various officers who have collected and forwarded it.

14. Rainfall Registration.

The registration of rainfall in India has always been carried out by the provincial authorities. In 1889 a uniform system was introduced by the Government of India, and the Director-General of Observatories was made consulting officer in connection with this work. His advice is sought regarding the starting of new raingauge stations, and he receives annual reports upon the efficiency of the work from the local controlling officers who are in most of the provinces the Directors of Agriculture or of Land Records.

The following is a statement of the number of raingauge stations supplying data for publication in the "Rainfall of India" as they stood in March 1923 :—

Province.	Number of stations.	Province.	Number of stations.
Burma	238	Baluchistan	85
Assam	126	Rajputana	178
Bengal	251	Central India	96
Bihar and Orissa	313	Central Provinces and Berar ..	189
United Provinces	276	Bombay and Sind	289
Punjab	191	Hyderabad	18
Kashmir	39	Mysore (excluding raingauges in taluks).	77
North-West Frontier Province ..	35	Madras (including feudatory States)	525

In 1920 the necessity of frequent inspections of raingauges was brought to the notice of the officers in charge of rainfall registration, and subsequent reports have shown a decided improvement in this respect.

The following notes are based on the reports for 1922-23 of these officers :—

Burma.—There were 237 stations as against 230 last year. Out of these 18 were meteorological observatories, 29 were under the Public Works Department, 2 belonged to the Agricultural Department, and the rest were supervised by civil officers. One hundred and ninety-two raingauge stations were inspected during the year, out of which 160 were reported good and the remainder in fair condition ; the chief defects reported were, as usual, nearness to buildings and trees.

Assam.—Two stations were closed during the year and three stations opened ; on the 31st March 1923 there were 126 raingauge stations. The number of inspections reported is 150 against 160 of last year. The stations inspected were 110 against 114, and those not inspected 16 against 11 of last year.

Bengal.—Five new stations were opened during the year making a total of 251. Of these only 109 were inspected during the year ; the corresponding figure last year was 151. The smaller inspection list in 1922-23 was due to the curtailment of travelling grants.

Bihar and Orissa.—The number of stations was 313 including 29 stations in the Feudatory States and Tributary Mahals of Orissa. Inspection reports received (including those of a few stations inspected twice) numbered 264. According to District Officers' reports about 16 per cent. of stations were not inspected, but inspection cards were not received from 36 per cent. of the stations. It appears therefore that in 20 per cent. of the stations although inspected the reports did not reach the Agriculture Department. Steps are being taken to remedy the position disclosed.

United Provinces.—There were 288 stations including meteorological observatories: out of 272 stations under the supervision of district and canal officers, 74 per cent. were inspected as compared with 43 per cent. in the previous year.

The Punjab.—(Report of the Director of Land Records, for calendar year 1922). All the raingauges in charge of civil officers are in good condition, the number inspected once or twice being 115. Report from Karnal district is wanting. The raingauges in charge of canal officers are in good working order and officers have been inspecting them from time to time. Enquiries as to whether there were any stations in charge of district officers not included in the Monthly Rainfall Statement show that there are no such stations.

Kashmir.—The Meteorological Reporter states:—"The number of raingauges is 39 in all, out of which 31 are merely rain recording stations and 8 are meteorological observatories. The number of inspections of raingauge stations made during the year was 19 against 14 of last year, which is satisfactory."

North-West Frontier Province.—A paragraph dealing with raingauge inspection in the Annual Report of Land Records and Agriculture for 1921-22 states:—"The instructions for inspecting at least 75 per cent. of the raingauge stations each year have been complied with in all the districts except Kohat, where no raingauge station was inspected during the year. Necessary orders have been issued to the officers concerned to comply with the instructions." Twenty-eight raingauges were inspected during the year and practically all were in good working order.

Baluchistan.—The Revenue Commissioner writes:—"The raingauges in the Agency were regularly read by persons in charge and inspected occasionally by various officers."

Bombay and Sind.—The Director of Agriculture writes among other things:—"..... out of a total of 278 gauges in the Presidency, as many as 206 or nearly 74 per cent. were inspected during the year under report as against 241 or 87 per cent. during the last year, while the total number of inspections during the year was 293 as against 354 of the previous year. In the Native States 37 gauges out of a total of 61 or nearly 61 per cent. were inspected during the year as against 54 or about 72 per cent. in the last year.

"These figures reveal the fact that the progress made during the previous year has not been maintained this year either in the Native States or the British districts. But though this is the case, when a comparison is made with the previous year, yet it compares well with the average number of inspections made during the years of the last quinquennium....."

"The salient feature of the year under report, however, was the very close scrutiny exercised with regard to the Raingauge Inspection Reports received in this office. Every defect, however small, was brought to the notice of the proper authority and suggestions made till it was removed."

Central Provinces.—The number of inspections of raingauge stations in the Central Provinces during the year was 155 against 106 in the previous year and 202 in 1920-21. In Berar the number was 44 against 64 in the last year. It is stated that in 12 districts the inspecting officers had not made sufficient inspections in conformity with the instructions contained in paragraph 10 of Revenue Book Circular III-2.

Hyderabad.—The Superintending Engineer, Eastern Circle, states that 4 raingauge stations were inspected.

Mysore.—The number of stations in the Mysore State for recording rainfall was 226. The inspection of raingauges was on the whole satisfactory as 199 were inspected during this year against 184 in the previous year; expressed in percentages there was a rise from 81 to 88.

Madras.—The total number of raingauge stations in the Madras Presidency on the 31st March 1923 was 395, of these 355 were inspected or 90 per cent. as against 92 per cent. last year.

A general review of these reports shows that in Burma, Assam, Bihar and Orissa, the North-West Frontier Province, the Central Provinces, Mysore and Madras the proportion of inspection of raingauge stations was over 75 per cent., in the United Provinces and Bombay it was 74 per cent., in Kashmir and the Punjab it was about 60 per cent., while in Bengal and Hyderabad it was 44 per cent. and 22 per cent., respectively.

Heavy Rainfall Reports.

Heavy rainfall is occasionally so very local that small areas can have as much as 10″ of rain without the Daily Weather Report conveying the least suggestion of it. With a view to have such useful data promptly available for the Daily Weather Report it had been arranged in 1921 with the approval of the Government of India that reports of 5 inches or more of rainfall should be telegraphed to Simla from raingauge stations at district head-quarters throughout the country. Very few of such telegrams were received in 1921 because the system was organized after the monsoon season of that year. The number of such telegrams was 146 during 1922-23.

15. Seismograph observations.

Seismological observations were recorded throughout the year by two Omori-Ewing seismographs at Simla, two at Calcutta and one at Bombay, and by a Milne seismograph at Kodaikanal. At Bombay (Colaba) there continued in use also two horizontal pendulum seismographs with specially elongated arms in their recording apparatus: a new Milne-Shaw machine was put into use there in February 1923. All the seismic data collected at these places were sent to the Seismological Committee of the British Association.

16. Time Signals.

The observatories at Madras, Calcutta and Bombay determine time from star observations, and communicate it to the local ports by time-ball signals. The distribution of time over the country generally is made from the Madras Observatory by a signal transmitted daily at 16 hrs. over the Indian telegraph system. A wireless time signal for the use of ships is broadcasted automatically twice daily from the Alipore Observatory at 1-30 and 13-30 G. M. T. through the Calcutta radio station. Arrangements for setting up a transmitter for similar wireless time signals at Bombay are being made with the Telegraph Department.

All time work was done satisfactorily throughout the year.

17. Publications.

Under the stress of the necessity to economise, important changes in the routine publications were carried out or decided upon during the year. The Monthly Weather Review, which was in arrears, had to be abolished from January 1921, and replaced by a Monthly Weather Report which was started from January 1923. For the intervening period the issues of the Annual Summary for 1921 and 1922 will be enlarged so as to embody all the monthly data.

With a view to further economy it was decided to stop periodically the provincial daily weather reports, the period of suspension for Bombay being fixed as 1st November to 30th April, for Madras 1st January to 31st March, and for Calcutta 15th November to 31st December; the change was brought into force from 1st January 1923.

As usual the Daily Weather Telegram was despatched to subscribers regularly about noon, and the weekly rainfall summary was supplied to the *Gazette of India* and to press correspondents in Simla.

In October 1922 was started a new Weekly Weather Report containing matter similar to that in the weekly summary published in the *Gazette of India*, and meant principally for prompt supply of information to the commercial public. Under

existing arrangements it will be published only during the monsoon period, *i.e.*, June to October.

The quinquennial volume of the Bombay Observatory has given place to an Annual Volume presenting the data in a modified form of two-hourly values of the more important elements recorded.

The routine publications of the department remain otherwise unchanged and the list of such publications as it stands now is given below :—

1. Indian Daily Weather Report.
2. Weekly Weather Report.
3. Monthly Weather Report.
4. Annual Supplement to the Daily Weather Report.
5. India Weather Review (Annual Summary).
6. Daily Rainfall of India.
7. Monthly Rainfall of India.
8. Report on the Administration of the Meteorological Department of the Government of India.
9. Memorandum on the probable character of the weather in north-west India in January, February and March.
10. Memorandum regarding the probable amount of monsoon rainfall.
11. Memorandum on the rainfall of June, July and the probable amount during August and September.
12. Statement of the rainfall and snowfall of north-west India in January, February and March, and a comparison of the seasonal forecast with the actual precipitation.
13. Statement of actual rainfall in June, July, August and September, and a comparison of the forecasts with the actual rainfall.
14. Kodaikanal Observatory Bulletins.
15. Annual Report of the Kodaikanal Observatory.
16. Calcutta Daily Weather Report.
17. Bombay Daily Weather Report.
18. Madras Daily Weather Report.

The following memoirs of the Indian Meteorological Department were published during the year :—

Volume XXIII, Part III, " Mean monthly characters of Upper Air winds deduced from the flights of pilot balloons at thirteen stations in India during the period 1910 to 1919 ", by J. H. Field.

Volume XXIII, Part IV, " The effects of oscillations and of 'lag' on the readings of the Kew pattern barometer ", by E. P. Harrison.

Volume XXIII, Part V, " On cleaning and refilling various types of barometer, together with a description of several usual patterns ", by E. P. Harrison.

Volume XXIV, Part I, " On the seat of activity in the Upper Air ", by P. C. Mahalanobis.

Volume XXIV, Part II, " On errors of observation and upper air relationships ", by P. C. Mahalanobis.

Volume XXIV, Part III, " On exposures of thermometers in India ", by J. H. Field.

18. Library.

Of books and pamphlets, 632 were either purchased or received as presentation copies from scientific bodies for the libraries in Simla and Calcutta during the year.

In the Simla library the work of classification based on the schedule of the International Catalogue of Scientific Literature made further progress, current books and pamphlets were classified immediately on receipt. During the year 2,104 books and pamphlets were catalogued and card-indexed, according to subject and author.

19. Concluding Remarks.

The Meteorological Department owes a large part of its usefulness to the sympathetic assistance it receives from outside departments. Civil Surgeons and other officers of Government departments, as unpaid superintendents of observatories and in other capacities, help in the meteorological work; the Telegraph and Postal Departments assist in every way in the rapid transmission of meteorological information; at the same time they allow their employees to act as observers. The Indo-European Telegraph Department, also, by giving free transit to the daily messages of the Persian observatories, places a large amount of most useful information at the disposal of the Meteorological Department. Weekly telegrams were received from May to September from the Director of the Royal Alfred Observatory, Mauritius, as well as from the departmental observatories at Zanzibar and Seychelles. These telegrams gave valuable information of the weather conditions in the Indian Ocean and the department is indebted to the officers indicated for the punctual transmission of the information. Thanks are especially due to the Director of the Royal Alfred Observatory for his courtesy in placing the meteorological data of that observatory at the disposal of the Indian Meteorological Department.

The department is greatly indebted for important information about meteorological conditions prevailing before and during the south-west monsoon to the Controller, Physical Department, Cairo; the Directors of the Observatories at Buenos Ayres, Santiago and Batavia; the Astronomer Royal, Cape Town; Director, L'Observatoire Physique Central, Petrograd; M. Thorkell Thorkelsson, Löggildingarstofan, Reykjavik, Iceland; the Director of the Meteorological Services of the Azores, Ponta Delgada, and to the various officers around the Indian frontiers who have collected and supplied valuable snowfall information.

The thanks of the Department are also due to Mr. A. J. Bamford, Superintendent, Colombo Observatory for the very useful help he has rendered from time to time in connection with storm warning work.

Simla; J. H. FIELD,

The 6th August 1923. *Offg. Director-General of Observatories.*

M 6 D66fO—23-8-23—320—GIPS.

Upper Air Work.

Incidents and instruments.

(For explanation see para. 8.)

Fig. 1.

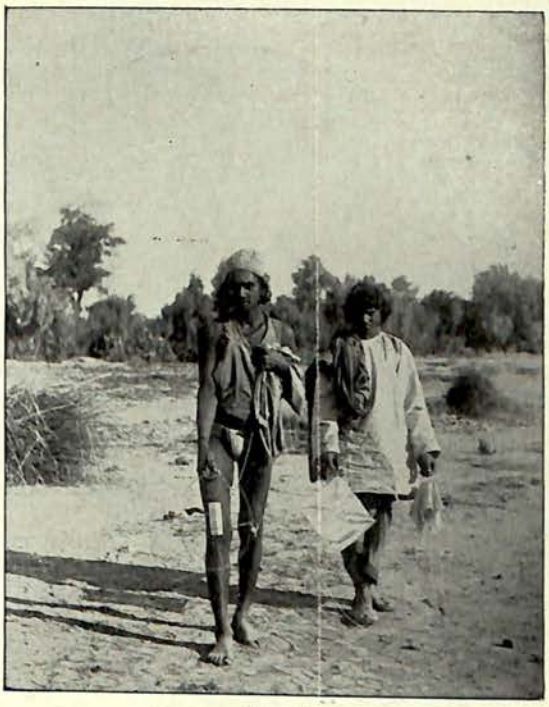


Fig. 2.

Fig. 3.

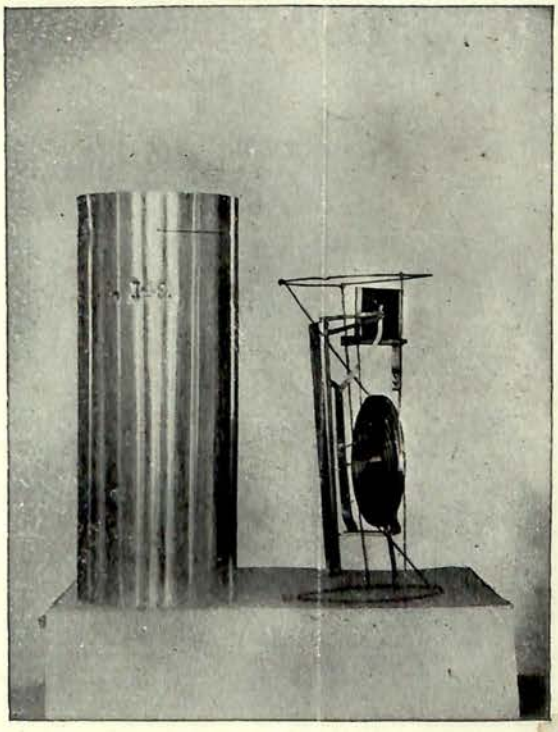


Fig. 4.

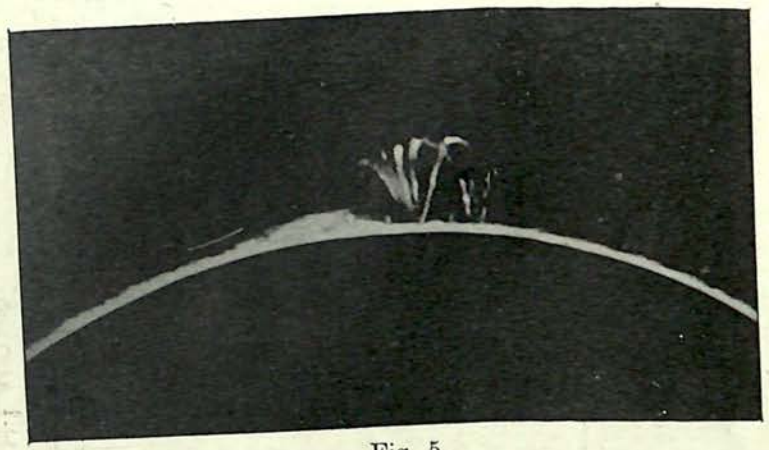


Fig. 5.

Fig. 6.

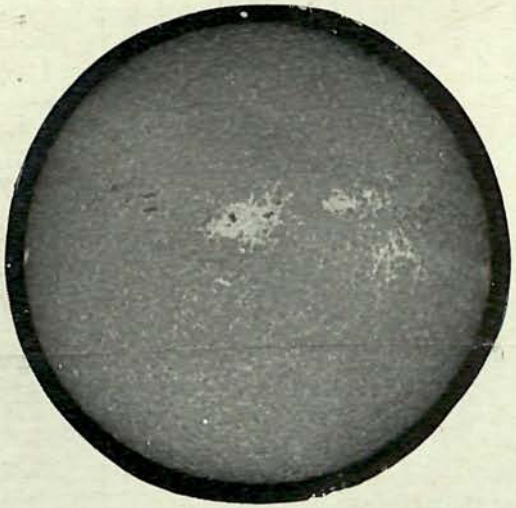


Fig. 7.

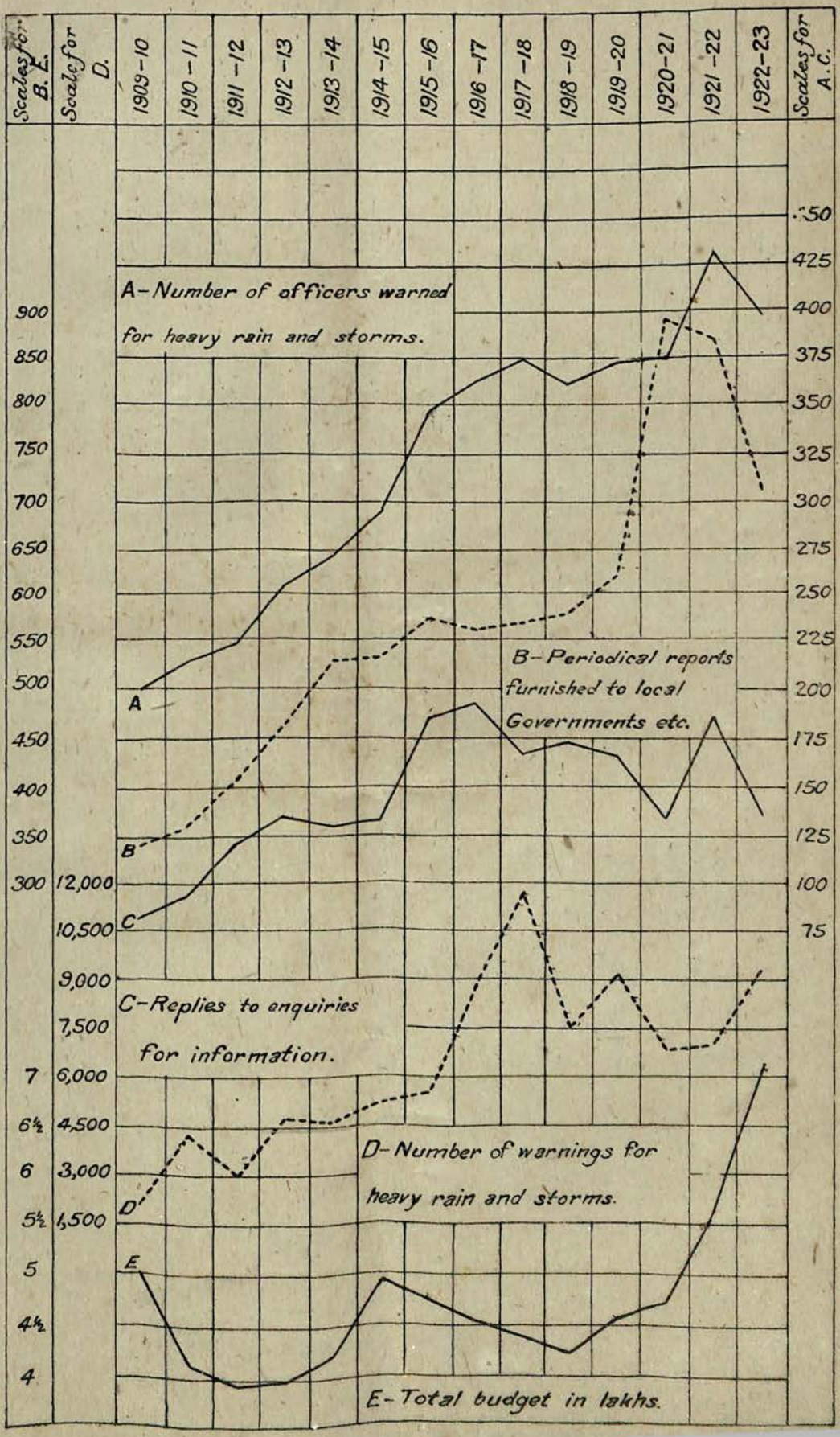
Sunspots : showing rotation of the sun.

Fig. 8.

Kodaikanal Observatory.

(For explanation see para. 10.

GROWTH IN ACTIVITY AND COST



Report on the Administration of the Meteorological Department of the Government of India in 1923-24.

SIMLA
GOVERNMENT OF INDIA PRESS
1924

Price 2 Annas.

BOMBAY BRANCH
OF THE
Royal Asiatic Society.

REPORT ON THE ADMINISTRATION OF THE METEOROLOGICAL DEPARTMENT OF THE GOVERNMENT OF INDIA IN 1923-24.

1. Chief features of the year.

Retrenchment has been one of the chief features of the year. The main objects of expenditure in the department have always been telegrams and pay of establishment, and both have become twice as expensive as they were in 1909; yet the departmental budget, which stood at 5 lakhs in 1909 and 1914 was limited to 6·2 lakhs for 1924-25. It was possible to make a few retrenchments in establishment and by drastic restrictions in the free distribution lists of the various weather reports; but the main curtailment of expenditure had to be effected in telegraphic charges. In consequence the issue of the Calcutta, Bombay and Madras reports was restricted to periods of 10½, 6 and 9 months respectively; and the number of stations reporting daily to Calcutta and Madras was greatly curtailed. Vigorous protests against some of these measures have been made by newspapers and by various associations, such as the Chambers of Commerce of Bengal, Bombay, Madras and Narayanganj, the Associated Chambers of Commerce for India and the Association of Marine Insurance Agents. The Committee of Inquiry on the loss of the S.S. "Okara" also criticised the new arrangements in so far as they involve the issue of storm-warnings for the Bay from Simla instead of from Calcutta.

In some ways however the outlook has improved. After many years of serious shortage of gazetted staff at headquarters, the last vacant post of our sanctioned establishment has been filled up, thus rendering possible the task of beginning to clear up the arrears of work, which have been accumulating in recent years. The Monthly Weather Reports, of which publication ceased for some time during the war, have been brought up-to-date; and a beginning has been made with the preparation of type-maps of Indian weather and of revised charts of storm tracks in the Indian Seas. A fairly adequate programme of inspection, the first for many years, was also carried through in spite of an originally insufficient grant for travelling allowance; it was an unexpected saving from the grant for establishment that provided the necessary funds.

The services of cyclone warnings to ports and shipping and of flood warnings to officers in the irrigation, railway and other departments were on the whole well carried out. Four storms formed in the Bay and one in the Arabian Sea, the most severe being the May cyclone in the Bay, in which the S.S. "Okara" was lost. The Court of Inquiry on the loss of that ship expressed dissatisfaction with the warnings broadcasted to ships during the storm: but it was not realised that the observations from ships were scanty owing to the recency of the introduction of the system of wireless information from them. In spite of that the situation was correctly described in messages broadcasted, at hours fixed in consultation with the Admiralty, from the 2nd May when it was said that a storm might be forming until the storm passed inland on the 6th: and in spite of the incompleteness of the observations the greatest difference between the position of the storm as broadcasted and its actual position *at that time of broadcasting* was only 85 miles, a fact which disposes of complaints of delay and speaks well for the accuracy of the warnings issued.

It was not until 2 hrs. of the 4th that the first definite evidence of a storm was received at meteorological headquarters in a telegram giving information of a heavy swell at the Sandheads ; and on the 3rd therefore there was a strong feeling of uncertainty about even the existence of a storm. It is true that on the 3rd, after a broadcast message at 7 A.M. saying that a storm had probably formed, a telegram that a storm had formed and was probably moving northeastwards was sent at noon to the Port Officer at Calcutta, but this was only an explanation of the instruction to hoist a warning signal. To the criticism that the broadcasting of this telegram, which gave actually too northerly a position of the storm, might have saved the "Okara" the reply is that if a message had been broadcasted at that hour it must have been couched in less definite language like that which preceded it, experience having shown that it is undesirable and even dangerous to broadcast to ships speculative opinions extending to details. Hence the department is of opinion that its inferences, founded on a slender basis of facts, were proved by subsequent events to be correct at the time of broadcasting and were issued in as detailed a form as was justified by the information available.

The Department has continued the work on upper air movement and has resumed regular observations on the temperature, pressure and humidity in the upper air above Agra, an activity which had to be stopped during the war. The military authorities, having found upper air observations to be essential in connection with the laying of guns in India as in Europe, sent a number of men to the Agra Observatory for the necessary observational training ; these now carry out the observations at artillery practice camps, using apparatus and materials supplied by the Agra Observatory.

In the field of meteorological research several memoirs have appeared during the year. Mr. Field has discussed the methods of upper air investigation and Mr. Harwood has produced three valuable studies of upper air conditions as derived from observations with balloons, kites and clouds. Sir Gilbert Walker has in a preliminary examination of some of the relations of weather over the world found several factors that will lead to greater reliability in forecasting the monsoon.

Old standing inconveniences in the Simla Office, namely the housing of a large part of the library in Benmore two miles distant, and the want of a laboratory room, have been removed during the year by the grant of four rooms in a neighbouring building and by making slight structural alterations to the office. Permission was also given to start building the much needed new engine house at the Agra Observatory.

2. Leave and appointments.

Sir Gilbert Walker returned from 8 months' leave on 8th October 1923, up to which date Mr. J. H. Field officiated as Director-General of Observatories.

Mr. J. H. Field proceeded on combined leave for one year from the 19th October 1923.

Mr. V. V. Sohoni was on 15 days' leave from the 23rd May to the 6th June 1923 inclusive.

Mr. G. Chatterji returned from leave on the 29th April 1923.

Dr. S. R. U. Savoor was on leave from the 5th to 26th June 1923.

The part-time post of Meteorologist, Bombay, was abolished from the 21st April 1923, and the Meteorological Office amalgamated with the Colaba Observatory under the Director of Colaba and Alibag Observatories, who was designated Meteorologist, Bombay, from that date.

3. The system of storm warning.

The work of warning ports and shipping in the Arabian Sea and the Bay of Bengal of the approach of cyclonic storms or of bad weather was done throughout the year from Simla. Thirty-two ports are on the warning list for storms in the Arabian Sea, and forty ports and fifteen River Police Stations for storms in the Bay; of the Bay ports thirteen get additional information regarding the particular areas in which weather is disturbed, a special system of 'locality signals' being in use for this purpose. Shipping at sea is also supplied with the latest weather information by means of wireless bulletins, which are broadcasted twice daily, or more frequently if the occasion demands it, from the radio stations at Bombay, Karachi, Calcutta, Rangoon, Madras, Matara (Ceylon) and Aden. The weather bulletins from Matara and Aden were started in March 1920 at the request of the Admiralty. A complete account of the warning system may be found in the "Code of Storm Warning Signals for use at Indian Ports", obtainable at Calcutta from the Superintendent of Government Printing, India.

4. Warnings for storms in the Bay of Bengal.

During the year warnings were issued for fourteen periods of disturbed weather; the disturbances developed into moderate storms during three of these periods, and into cyclones during two.

The "Okara" Cyclone.—The first of these two cyclones occurred in front of a temporary advance of monsoon in the Bay, which began in the last week of April and gave rise to a short-lived storm off the Arakan coast between the 27th and 29th and later to a low pressure area off the Madras coast. The latter became a well-formed depression by the morning of the 2nd May with centre near 13½°N., 85½° E. Moving in a NNE direction the depression had probably developed into a storm by the morning of the 3rd May with centre near 16° N., 86½° E. Although there were no steamers near the central area during that day, we have, nevertheless, some justification for thinking that the storm then became a severe cyclone, inasmuch as the S. S. "Huntsman" more than 250 miles south of the centre had strong south-westerly winds with a rough following sea and the pilot vessel at the Sandheads began to experience a tremendous swell in the early morning of the 4th. By 8 hrs. of the 4th the centre lay near 18½° N., 88° E. and its path was roughly NE during the day, changing to ENE next day; the storm centre ultimately crossed the coast about 25 miles south of Cox's Bazar at 9 hrs. of the 6th.

The S.S. "Okara", which left the Sandheads in the early morning of the 3rd, was probably caught in the dangerous northeast quadrant of the cyclone on the morning of the 4th and foundered on the night of the 5th. When she sent out her last S. O. S. signal she estimated her position to be near 19° N., 91° E.

The experience of the S.S. "Chinkoa" illustrates the danger which low-powered vessels undergo in severe cyclones. She had been manœuvring off the Arakan coast throughout the 4th in an attempt to avoid the inner storm area and then headed north after midnight. As the gale and seas were increasing, she turned towards the southwest but found no improvement. At 9 A.M. of the 5th the vessel was thought to be some 80 miles west-south-west of Kyaukpyu and Captain Johnson wishing to avoid being caught near the "Terribles" decided to head northwest with the hope of crossing into shallow water in the less dangerous half of the storm. But as the storm was now moving ENE towards the Cox's Bazar coast the steamer was drawn right into the centre. About 21 hrs. she heard the S. O. S. signal from the ill-fated "Okara"; only ten minutes later she herself lost the

superstructure to bridge and deck outside the Captain's cabin, together with the mast-head lights. The wind and sea were so terrific that at midnight it was dangerous to try to stand on the bridge whence nothing could be seen but spray ; the crew while on deck had to lie down and hang on to the rails. The weather grew even worse until, after a terrific parting squall, the vessel entered the calm centre at 3 h. 30 m. of the 6th. In the words of the Captain " Suddenly the wind ceased and there was a death-like hush and you could hear the wind in the distance. The sky suddenly opened up in a large circle with white clouds and lightning playing incessantly and numerous birds falling on deck. My attention was at once drawn to the colour of the sea which resembled yellow mud ; on taking soundings I got 32 fathoms and at once took another cast and got 26 fathoms. I then noticed that all my tarpaulins and hatches were gone. As soon as the centre was on us the sea fell considerably and there was only a confused swell. I then headed the ship west ; at 4 h. 5 m. the wind (from a northerly direction) struck the ship with terrific force and put her on her beam ends for about 15 seconds ; at 4 h. 10 m. with wind from NW we paid off to WSW ; at 4 h. 15 m. wind from W we paid off to SW ; the wind from 4 h. 8 m. to 5 A. M. was terrific ; at 5 A. M. there was a tremendous confused sea and the wind was of hurricane force, barometer 28·53″, soundings 60 fathoms. At 8 A. M. weather moderating, barometer 29·31″ ; and at noon weather improving, squally at times."

It is interesting to note that as a result of the three days' buffeting by wind and sea the Captain of the S.S. " Chinkoa " was 100 miles out in his reckoned position. Similarly the Captain of the S.S. " Angora ", who was running up the Bay behind the storm and experienced less severe weather than the " Chinkoa," found later that he had been 25 miles ESE of his reckoning. In view of certain statements in the following paragraph, it is worth noting that this difficulty of reckoning position accurately during storms will always, even when all ships co-operate in sending wireless weather messages, be liable to give rise to errors of 25 or even 50 miles in the determination of the position of a storm's centre at sea.

5. The loss of the " Okara " in this storm led to a court of enquiry under section 248 of the Indian Merchant Shipping Act, 1923 ; and as their findings have led to much criticism by the public of the financial policy of government as well as the organisation of the department it seems necessary to deal with them at some length. The questions before the court were (1) the fitness of the " Okara " to put to sea, (2) its loading, (3) the prudence of the Master in proceeding to sea in view of the weather prevalent, (4) the causes which led to the foundering of the vessel, and (5) the action of Calcutta wireless station regarding the S. O. S. signals : and in relation to (4) the court considered it ' probable that the "Okara" would not have been lost ' if a certain message sent to the Port Officer, Calcutta, had been ' broadcasted or sent TTT at noon '. This was actually sent to the Port Officer as a brief explanation of instructions to him to hoist a warning signal, and would have been made much less definite if it had been thought well to send an additional broadcast, which from the departmental standpoint would have been useless as the position of the storm had already been indicated with all the accuracy available : the court in effect endorsed this accuracy when it found that the information sent at 7 A. M. and 7 P. M. on the 3rd May gave the position of the storm as some 50 miles south of its actual position. It must be remembered that a storm is in general over 150 miles in diameter, and has no definite boundaries, so that its centre is not easily fixed : we do not even now know the position of the centre on the 3rd to nearer than 40 miles.

With reference to the criticism that the department did not use the TTT signal, no such system of signalling existed in India at the time, and telegraphic arrange

ments for it have only been made since the storm in question. It is held by the department that the precision attainable in forecasting was over estimated by the court : none of the positions broadcasted during the existence of the storm was more than 85 miles from the position *at the time of broadcasting* as now estimated from all the information available, and this fact in reality reflects considerable credit on our staff : accordingly complaints of delay and inaccuracy are in our view difficult to maintain, especially in view of the very scanty information received from ships owing to the short time that had lapsed since the wireless system had been reintroduced, and the consequent lack of full co-operation between the department and the shipping.

The court also recommended ' that the question whether important weather messages should be broadcasted immediately instead of twice a day at fixed hours should be considered '. This has always been our practice : our hours of routine broadcasting, namely 1 P. M. and 1 A. M. were altered under advice of the Admiralty to 7 P. M. and 7 A. M. in order to be during the periods when all vessels with wireless will have an operator on duty. However an improved system has recently been introduced under which in disturbed weather three broadcast messages are sent out at eight-hour intervals which are supplemented by special TTT messages when important information of an unexpected character comes to hand, and by intermediate messages at four-hour intervals if the storm is approaching the coast and there is sufficient information available.

The recommendation which has roused most interest is that of ' consideration of the advisibility of having the Meteorologist who deals with the Bay of Bengal storms posted in Calcutta instead of Simla, as at present '. But at Simla the work is shared among four meteorological officers assisted by two assistant meteorologists, and to transfer most of these to Calcutta is impracticable without moving the headquarters there, a change which is at present impossible on other grounds. There is far less likelihood of neglecting a détail of importance if the work is done by the full Simla staff than by one meteorologist at Calcutta, and the physical strain of watching a storm by night as well as by day for long periods, not infrequently involving duty on ten consecutive nights, is more easily borne at Simla. That the strain leads to inefficiency at Calcutta may be demonstrated from the experience of the last five years of warning by the Calcutta office, though the Meteorologists in charge have been men of marked ability and of a high sense of duty : it will suffice to allude to the cyclone which did great damage in south-east Bengal on the afternoon of the 24th September 1919 : owing to a definite error of judgment no warning was given by the Calcutta Meteorologist although the Simla office published the probable formation of the storm on the morning of the 23rd. The department hopes that much of the disadvantage that is urged as arising from our lack of intercourse with ships ' captains may be met by arranging for a senior meteorologist to spend in Calcutta annually as much time as can be arranged ; and that the securing of adequate information from ships, in which considerable improvement has already been effected, will be promoted by adopting the same system as in England and America, of providing those captains who co-operate with special barometers or barographs and definitely cultivating relations with them instead of asking them to carry out their meteorological work from a sense of duty alone.

6. *Cyclone of 10th-18th November 1923.*—Unsettled conditions appeared to the south of the Andaman Sea on the 6th and passing westward gradually developed into a storm which on the morning of the 10th had its centre near 10½° N., 90° E. Moving in a west-north-westerly direction it lay near 12° N., 86½° E. on the morning of the 12th and near 12½° N., 84½° E. on the morning of the 13th. Its direction then changed

to north-west till it reached 14° N., 83½° E. on the morning of the 14th and subsequently to nearly north until it crossed the coast a little to the north of Vizagapatam on the night of the 17th ; later on the storm travelled parallel to the coast, weakening at the same time and reaching south Orissa on the morning of the 19th, whence it passed across the head of the Bay as a residual depression, becoming unimportant by the night of the 20th. In the opinion of the Collector of Vizagapatam the results of this storm surpassed all recorded disasters in that district since 1868. The railway was breached at many places along a considerable length owing to the very heavy rain caused by the storm as it passed through the narrow strip between the coast and the ghats. The town of Waltair-Vizagapatam suffered most from the high winds : the death-roll was about 75, and there was extensive damage to house property and very general destruction of the thatched houses of the poorest classes. The port of Vizagapatam, however, suffered little damage. In the district of Godaveri and the northern portion of Ganjam, as well as in Puri, the damage was slight. The warnings issued for this storm were mostly correct : the " danger " signal was hoisted on the morning of the 16th November at Vizagapatam about 36 hours before the storm passed inland ; in the light of later events we see that the " great danger " signal would have been more suitable, but reports from ships at sea had indicated the storm to be one of moderate intensity without the small inner area of hurricane winds which it subsequently proved to have over Vizagapatam. The Port Conservator, Gopalpur states " the storm telegrams (23 in number) received by me from Simla during the recent cyclonic period have proved of great help and immense necessity in giving local warnings and preventing casualties to shipping ".

7. Warnings for storms in the Arabian Sea during the year.

The west coast ports are warned not only for storms but also for squally weather, especially at the beginning of the monsoon. There were 8 periods of disturbed weather for which warnings were issued : during 5 of these the warnings were for squally weather or strong winds connected with the monsoon and during 2 for rough weather off the Mekran coast due to the passage of a western depression through Baluchistan. In the remaining period the warnings were for a cyclone. This cyclone was first noticed on the morning of the 20th December, when the *S.S. Polyphemus* reported very rough seas and S.W. gales from Lat. 10½° N., Long. 65½° E.: wireless information was meagre on the following days, and the storm must have moved westwards or north-westwards and dissipated itself in the middle or west of the Arabian Sea. It was apparently severe, though of very small extent, and had advanced from the Bay as an ill-defined disturbance and developed in the southeast of the Arabian Sea.

The observations of the coast stations did not at any time indicate the existence of a storm in the Arabian Sea, and the information from ships was also scanty. In view of these circumstances the warnings issued were as correct as they could be.

8. Flood and storm warning, and weather forecasts to district irrigation, railway and other officers.

This work was done wholly by the Simla Meteorological Office. The arrangements have been made at various times and differ considerably in character, according to the nature and extent of the flood or weather warnings required by those concerned. In most cases the officers require telegrams either warning them of advancing storms likely to give heavy rain or informing them of the actual occurrence of heavy

rainfall likely to give rise to severe floods which might injure railways or canal works ; and in other cases, they require warnings or forecasts of the weather for as long a period beforehand as possible.

At the end of the year the number on our lists of district officers and officers in the irrigation, railway and other departments to whom flood warnings, weather forecasts or intimations of the likelihood of rain during the dry season were to be sent by this department was 214. There were also 20 officers of the Telegraph Department requiring warnings, mostly for strong winds.

In order to provide against serious loss of life and property in inland Bengal when a cyclone from the Bay crosses the coast, 461 officers were added in 1921 to the warning list ; of these officers 40 hoist the signals shown in Appendix D of the " Code of Storm Warning Signals " whenever warned to do so.

The number of special forecasts and warning messages issued by the Department during the year was 2,162, and in addition 882 telegrams of actual heavy rainfall were sent by meteorological observers direct to various officers.

Instructions were issued by the Government of India in 1898 that every officer to whom storm or flood warnings are sent should in the month of January of each year or, in the case of military expeditions, at the close of the campaign, forward to the head of this department a brief return of the warnings received and should also report whether the warnings were satisfactory and whether any changes might be made to increase the usefulness of the warnings.

Reports on the storm and flood warnings for the calendar year 1923 were received from 51 officers. Of these 31 stated that the warnings were satisfactory, 14 gave no remarks and the remaining 6 offered minor suggestions or criticisms, which have been attended to. On the whole a comparison of the warnings with the actual subsequent rainfall or the tracks of storms inland show that the system is working satisfactorily and that most of the warnings issued were of value to the recipients. As illustrations the following extracts from reports may be of interest :—

The Collector of Chittagong wrote with reference to the warnings issued during the Okara ' cyclone ' that " the meteorological warnings were of great value to me and have been much appreciated by the people living near or at the Headquarters town of Chittagong as well as at the Sub-divisional Headquarters of Cox's Bazar."

The Superintending Engineer, Indus Left Bank Division, stated that " warnings conveyed by them (telegrams) were generally timely and met requirements."

The Chief Engineer in Sind, stated that " the warnings were timely and satisfactory in every respect and no change in the system is wanted. I appreciate the care and regularity with which the warnings are issued by the Meteorological Department."

9. *Warnings to Military Authorities in Waziristan.*—Telegraphic forecasts of the likelihood of bad weather were sent throughout the year to seven different and changing centres in connection with the Waziristan field operations. No opinions have come to hand as to their utility.

10. Supply of Meteorological Information.

From time to time special information is supplied to the meteorological departments of England, Australia and Egypt. Climatological and other data, at times involving special calculations, are also provided for sanitary and other officers of

Government as well as for those private firms who are willing to pay for the service. The extent to which the department was utilized in this manner during the last year will be seen from the curves B and C in the graph at the end of this report.

11. Upper Air Work.

The outstanding feature regarding the upper air work which centres round the Agra Observatory was the resumption of meteorograph flights in November 1923; and it is interesting to note that of the 36 'instrument balloons' let off before the end of the year 21 were recovered.

The other activities of the Upper Air Observatory were carried on on the lines indicated in the last year's report. Pilot balloon work was started again at Bombay and Peshawar: and a revised code for sending upper air telegrams to Simla was brought into force from 1st January 1924.

As an extension of upper air work was anticipated on various grounds and the equipment was inadequate for present needs, plans for a bigger plant for generation of hydrogen were prepared. The proposals for the construction of a new engine house were submitted to Government in April 1923. These were sanctioned and the work was started in November 1923 under the direct supervision of the Meteorologist; it is expected to be finished during the current year.

The work of the 'meteor' parties, organised for the artillery practice camps, was found very valuable by the military authorities during the previous year, and as requirements could not be fully met by staff available at Agra, the military authorities decided to send some of their men to Agra for training in balloon work. Three batches of non-commissioned officers, 8 in each batch, were thus trained and equipment for 'meteor' work was supplied by the Agra Observatory to 12 artillery practice camps during the year.

The workshop, in addition to dealing with repairs to instruments belonging to the department, made definite headway in the manufacture of Stevenson screens, which are gradually to replace the majority of thatched thermometer sheds.

A series of memoirs were published by Mr. J. H. Field and Dr. W. A. Harwood on 'The free atmosphere in India' describing the methods of research employed and containing a discussion of the upper air circulation in the monsoon and of past results of meteorograph flights and observations of cloud heights.

An extension of meteorograph flights is contemplated, with a view to the use of larger balloons capable of carrying meteorographs up to heights of 12 miles or more, where it is known from work in other countries that features of great importance can be observed.

12. Researches by the Simla Staff.

The intermission in the publication of the Calcutta, Bombay and Madras daily weather reports made it possible for a mass of computing to be effected, and considerable progress was made by the head of the department in his study of the relationships of seasonal weather over the world. The results of the calculations brought out a number of new facts and threw additional light on those previously known empirically. Over the region consisting of the Pacific Ocean (from the Aleutian Islands to the Antarctic), S. America, the Cape, Mauritius, southern Asia, and Australia there is a marked tendency for conditions in one definite group of areas to move in one direction, while those in a second group move in the opposite; and the consistency is such that of the 150 significant relationships between the variations

of 11 of these areas the sign of 149 is specified by merely assigning the 11 areas to their respective groups. The effect of this knowledge in the improvement of seasonal forecasting should be material.

13. Observatories.

Kodaikanal.—The Director of the Solar Physics Observatory published a report on the astronomical work for 1923.

The magnetic observations at Kodaikanal that used to be taken on behalf of the Survey of India were discontinued from the 1st October 1923 at the request of that department. The work of collecting spectroheliograms from other observatories for days on which observations could not be made at Kodaikanal was carried on as a part of the programme of the International Astronomical Union. Meteorological and seismological observations are as usual published in the Annual Summaries of the India Weather Review.

Bombay, Colaba.—The most important event of the year was the amalgamation of the Bombay Meteorological Office with the Colaba Observatory from 22nd April 1923. The Daily Weather Report was published for the 6 months, May to October; its free distribution was discontinued and the monthly subscription raised from Rs. 2 to Rs. 3-8-0. In addition to the routine work of computation a large number of correlation coefficients were calculated for the Simla Office, and progress was made with the calculation of hourly normals of meteorological elements from the data from 1846 to 1920. Two important routine activities are the rating of chronometers for Royal Indian Marine and Royal Navy ships and extracting meteorological notes from logs of vessels; nine hundred logs were so dealt with for the department. A new Dines' anemograph and a new collimator were installed. An investigation on earth currents, associated with diurnal magnetic variations, was undertaken by the Meteorologist.

Bombay, Alibag.—Although the working of the magnetic observatory has been on the whole good, a serious trouble arose during the monsoon when it was found that the roof of the magnetometer building was in a very decayed condition and allowed considerable leakage. Prompt measures were however taken and it is hoped that the roof will be made perfectly sound before the next monsoon.

Madras.—The most important routine work here is the supply of time to the local shipping and the issue of a daily weather report during the nine months, April to December. The work of the rainfall organization in the presidency which was in the charge of the Meteorologist was transferred to the Board of Revenue of the Madras Government from the 1st January 1924.

Calcutta, Alipore.—In addition to the issue of the Daily Weather Report for northeast India, the Calcutta office and observatory have the important duties of supplying all the Indian observatories with instruments and stores, keeping a stock of tested instruments, checking and computing a portion of the data accumulated from the observatories, supplying mean local time to the Port of Calcutta and by wireless to shipping at sea; distributing the departmental publications and attending to some of the routine correspondence of the department as a whole.

About nine hundred instruments were tested at the Alipore Observatory during the year.

The precision clocks at the observatory were somewhat less satisfactory than in past years and a Dent clock has therefore been transferred temporarily from Madras to Alipore until the arrival of a new astronomical clock from England.

Other Observatories.—A number of observatories keep continuous records of certain meteorological elements ; 4 stations register wind, 6 sunshine, 15 pressure, 7 temperature, while one station records solar radiation, 9 terrestrial radiation and 2 underground temperatures.

14. Of the purely meteorological observatories under the department's care 46 were non-departmental and 214 were maintained by the Government of India ; these include stations as far afield as Tehran, Kashgar, Aden and Seychelles. According to the classification given in the report for 1918-19, the departmental observatories consisted this year of 5 of the first class, 185 of the third class, 5 of the fourth class and 25 of the fifth class. The maintenance of these observatories, the supply to them of tested instruments, and the careful scrutiny of their observations naturally entail much work of a routine character at headquarters. The correctness of observations depends upon the continuance of good exposure and good condition of instruments at observatories, and upon the accuracy of reading by observers. The former point can only be ensured by inspection visits of trained officers. The latter point can to some extent be estimated at headquarters from the number of mistakes detected in the data for the Indian Daily Weather Report. The stations of great reliability in which no mistake or at most one has been detected, numbered 26, and the number at which more than 50 mistakes were made was 4. The average number of mistakes during the year at the remaining stations was 11.

15. Inspection of Observatories.

Frequent inspections of observatories are essential for the maintenance of accuracy in results and as this feature had, perforce, been neglected for the last 5 years during which only 30 stations on the average were inspected annually it was felt imperative to begin making good in spite of financial constraint. Fortunately, savings accruing under other heads rendered this possible, and during the year 87 observatories, including most of the stations on the coast line from Rangoon to Karachi, were inspected by meteorologists and others, while the Director-General visited the principal observatories at Alipore, Madras, Kodaikanal, Bombay, Lahore and Agra. Provision for adequate inspection has happily been made for the current year.

16. Marine Meteorology.

Wireless weather messages from ships at sea and extracts from logs of ships calling at Bombay and Calcutta are the chief sources of marine data collected by the department.

The object of the system of radio-messages from ships is mainly to supplement the coast observations in cyclone warning work. In the absence of observations from sea areas it is not always easy to draw correct conclusions about the position, movement and intensity of storms ; this is the case particularly with disturbances in the Arabian Sea for which inferences had in the past to be drawn from very insufficient observations from the west coast line of India. This system, which was started in 1914 but which broke down during the war, was reorganised in 1921 ; it worked fairly well during the year under report and ships' messages were always useful. A satisfactory feature has been the increasing number of such messages received at Simla from both the Bay and the Arabian Sea, the total number being 2,237 as compared with 956 last year. The department gratefully acknowledges the assistance given by commanders of ships who took part in this service, and would

especially mention the following steamers from whom more than forty weather messages were received during the year :—

S. S. "Angora."	S. S. "Egra."	S. S. "Maharaja."
S. S. "Canara."	S. S. "Elephanta."	S. S. "Manipur."
R. I. M. S. "Clive."	S. S. "Havildar."	S. S. "Oxfordshire."
S. S. "City of London."	S. S. "Herefordshire."	S. S. "Shahjehan."
S. S. "Ellora."	S. S. "Kaiser-i-Hind."	S. S. "Sikh."

Clerks from the local offices of Calcutta and Bombay are entrusted with the work of visiting ships, copying the logs and determining the index corrections of ships' barometers. The number of ships visited is materially less than the arrivals but the information collected is as large as the available staff can deal with. The data thus obtained are utilised in the preparation of charts for disturbances in the Bay of Bengal and the Arabian Sea for future reference in connection with the storm warning work of the department, and in drawing up an account of the storms of the year for publication in the India Weather Review (Annual Summary).

17. Snowfall registration in the mountain districts to the north and west of India.

The information as to the amount, distribution and time of occurrence of the snowfall in the Himalayan and Afghan mountain areas was on the whole tolerably complete, and the thanks of the department are due to the various officers who collected and forwarded it.

18. Rainfall Registration.

The registration of rainfall in India has always been carried out by the provincial authorities. In 1889 a uniform system was introduced by the Government of India, and the Director-General of Observatories was made consulting officer in connection with this work. His advice is sought regarding the starting of new raingauge stations and he receives annual reports upon the efficiency of the work from the local controlling officers who are in most of the provinces the Directors of Agriculture or of Land Records.

The following is a statement of the number of raingauge stations supplying data for publication in the "Rainfall of India" as they stood in January 1924 :—

Province.	Number of stations.	Province.	Number of stations.
Burma	238	Baluchistan	79
Assam	124	Sind	14
Bengal	251	Rajputana	178
Bihar and Orissa	314	Bombay	274
United Provinces	276	Central India	104
Punjab	190	Central Provinces	189
Kashmir	39	Hyderabad	18
North-West Frontier Province ..	36	Mysore (excluding raingauges in taluks.)	77
		Madras (including Feudatory States.)	525

In 1920 the necessity of frequent inspections of raingauges was brought to the notice of the officers in charge of rainfall registration, and subsequent reports have shown a decided improvement in this respect.

The following notes are based on the reports for 1923-24 of these officers :—

Burma.—There were 238 stations as against 237 last year; 18 were meteorological observatories. 29 under the Public Works Department, 2 belonging to the Agricultural Department and the rest under the supervision of civil officers. 198 raingauges were inspected as against 155 in the previous year, out of which 164 were reported to be in good, and the rest in fair, condition; the main defects were as usual nearness to buildings and trees.

Assam.—There were 125 stations at the end of the year. The number of raingauges inspected was 105 against 110 in the preceding year. The districts are generally well equipped with raingauges and their accessories.

Bengal.—The number of raingauges at the end of the year was 250. The inspections showed considerable improvement, the number of stations visited being 202 as against 109 in the preceding year.

Bihar and Orissa.—There were 315 raingauges including 29 in the Feudatory and Tributary Mahals of Orissa, out of which 245 were inspected.

United Provinces.—There were 288 rain-reporting stations including the meteorological observatories. Out of 272 stations under District and Canal Officers 75 per cent. were inspected during the year as compared with 74 per cent. in the previous year.

The Punjab.—The Director of Land Records in his report for 1923 says :—

"The majority of the raingauges in this Province are placed on roofs and only about 40 on the ground. In Standing Order No. 37, paragraph 4, it is stated that it is desirable as far as possible to have raingauges on the ground and that where new raingauges are made they should always be placed on the ground. It should, however, be pointed out that my inspections and those of my Personal Assistant shew that it is impossible to adequately protect raingauges on the ground from animals and boys unless a defensive railing is provided, the cost of which would be about Rs. 250. But as this sum would have to be provided from the district contingencies which have been considerably cut down by the Council it is impossible to provide such railings where they do not already exist. It seems, therefore, desirable that either the Meteorological Department should provide some funds for such railings or should be content with the admittedly less desirable condition of raingauges on the roofs.

Apart from this there is nothing in the working of raingauges which calls for special notice."

North-West Frontier Province.—There were 33 raingauges: out of these 32 were inspected and reported to be in good working order.

Baluchistan.—There were 79 raingauges as against 74 in the last year. Twenty-six raingauges in charge of Civil Department were inspected by District Officers, while the railway raingauges were frequently inspected by the District Traffic Superintendent, Quetta.

Bombay and Sind.—There were 338 raingauges including those in Sind and the Native States; out of these 291 were inspected as against 243 during the preceding year. The Director of Agriculture says :—"Out of a total of 213 rain reporting stations in the Presidency proper as many as 180 or nearly 85 per cent. were inspected during the year as against 165 in the previous year. In Sind, out of a total of 64 raingauge stations the number of inspected stations rose from 41 in the last year to 57 in the current year or by as much as 90 per cent. The Native States also show a substantial progress in this respect—the number of stations having increased from 37 in the preceding year to 54 or very nearly 90 per cent. during the year under report.....

"Very close scrutiny was exercised as usual with regard to the raingauge inspection reports received from various officers. The attention of the officers concerned was drawn to every defect in the raingauge and they were repeatedly reminded till the defects were removed."

Rajputana.—Reports on the rainfall registration were received from the following States :—

(1) Dungarpur, (2) Kotah, (3) Nimrana (Alwar), (4) Jodhpur, (5) Jhalawar, (6) Bundi, (7) Tank, (8) Shahpura, (9) Banswara, (10) Partabgarh, (11) Jaipur, (12) Sirohi, (13) Udaipur (Mewar), (14) Karauli and (15) Jaisalmer.

Taking these States together there were 217 raingauge stations out of which 189 were inspected as against 131 last year. The condition of the raingauges was on the whole good.

Central India.—Reports on the rainfall registration were received from the following States and Agencies :—

(1) Jobat, (2) Jhabua, (3) Nagod, Jaso, Maihar and Rewah (Baghelkhand Agency), (4) Malwa Agency and (5) Bhopal.

There were 103 raingauges in all in the above States and Agencies out of which 94 stations were inspected as against 71 last year. The condition reported was on the whole good.

Central Provinces.—The number of raingauges in the Central Provinces was 126 and those in Berar 43, the number of inspections in the former being 292 and in the latter 97.

Hyderabad.—The Superintending Engineer, G. B. Eastern Circle, reports that 6 stations were inspected by him and "all the raingauges were also inspected by the respective Divisional Engineers."

Mysore.—The number of raingauge stations remained unchanged, *i.e.*, 226. Of these 77 are at district and taluk headquarters and the rest in villages. The percentage of number of stations inspected rose from 88 in the last year to 92; no less than 105 stations were inspected more than once and only 19 were left uninspected.

Coorg.—7 out of 10 raingauges were inspected and were found to be in good order.

Madras.—There were 400 raingauge stations in the Presidency on 31st March 1924. A year before the figure was 395 excluding the 27 meteorological observatories out of which 5 were abolished. The number of stations inspected during the year was 376. The condition of the raingauges was generally good. The rainfall registration was transferred during the year from the Meteorological Department to the Board of Revenue.

A general review of the report shows the satisfactory fact that in practically all the divisions over 75 per cent. of the raingauges were inspected.

19. *Heavy Rainfall Reports.*—Heavy rainfall is occasionally so very local that small areas can have as much as 10″ of rain without the Daily Weather Report conveying the least suggestion of it. With a view to have such useful data promptly available for the Daily Weather Report it had been arranged in 1921 with the approval of the Government of India that reports of 5 inches or more of rainfall should be telegraphed to Simla from raingauge stations at district headquarters throughout the country. The number of such telegrams was 218 during 1923-24, as compared with 146 in the previous year.

20. Seismograph Observations.

Seismological observations were recorded throughout the year by two Omori-Ewing seismographs at Simla, two at Calcutta and one at Bombay, and a Milne seismograph at Kodaikanal. At Bombay (Colaba) the new Milne-Shaw machine has worked excellently since its installation last year. All the seismic data collected at these places are sent to the Seismological Committee of the British Association.

21. Time Signals.

The observatories at Madras, Calcutta and Bombay determine time from star observations and communicate it to the local ports by time-ball signals. The distribution of time over the country generally is made from the Madras Observatory by a signal transmitted daily at 16 hrs. over the Indian telegraph system; considerable errors are inevitably introduced into the signal at stations where retransmission is effected by hand. A wireless time signal for the use of ships was broadcasted automatically twice daily from the Alipore Observatory at 1·30 and 13·30 G.M.T. through the Calcutta radio station.

All the time work was done fairly satisfactorily throughout the year.

22. Publications.

The position regarding the routine publications of the department described in last year's report remained unchanged. The Annual Summaries for 1921 and 1922 containing all the monthly data in addition to the usual matter were sent to press. The provincial daily weather reports remained suspended during certain selected periods; but towards the end of the year it was decided that, owing to its great importance to commercial and shipping interests, the Calcutta Daily Weather Report would be soon restored to its condition prior to curtailment.

The Daily Weather Telegram was despatched to subscribers daily about noon, and the weekly rainfall summary was supplied to the *Gazette of India* and to press correspondents in Simla. The Weekly Weather Report containing matter similar to the Weekly Summary published in the *Gazette of India* was published during the monsoon period.

The quinquennial volume for 1916-20 of the Bombay Observatory was prepared for the press, while considerable progress was also made with the Annual Volume for 1921.

The number of institutions on the distribution lists of the department was 404.

The following memoirs of the Indian Meteorological Department were published during the year :—

Volume XXIII, Part VI, " On Indian monsoon rainfall in relation to South American weather 1875-1914 ", by R. C. Mossman.

Volume XXIII, Part VII, " Monthly and annual normals of rainfall and of rainy days, from records upto 1920 ", by Gilbert T. Walker.

Volume XXIV, Part IV, " Correlation in seasonal variations of weather, VIII. A preliminary study of world-weather, by Gilbert T. Walker.

Volume XXIV, Part V, " The free atmosphere in India. Introduction," by J. H. Field.

Volume XXIV, Part VI, " The free atmosphere in India. Observations with kites and sounding balloons upto 1918 ", by W. A. Harwood.

Volume XXIV, Parts VII and VIII, " The free atmosphere in India.

7. Heights of clouds, and directions of free air movement.

8. Upper air movement in the Indian monsoons and its relation to the general circulation of the atmosphere ", by W. A. Harwood.

23. Library.

During the year 785 books and pamphlets were either purchased or received as presentation copies from scientific bodies for the libraries in Simla and Calcutta. In the Simla library the work of classification made further progress, current books and pamphlets being dealt with immediately on receipt. The arrears in classification of books and pamphlets have been practically cleared up, the number of publications catalogued and indexed being 603.

24. Concluding Remarks.

The Meteorological Department owes a large part of its usefulneess to the sympathetic assistance it receives from other departments. Civil Surgeons and other officers of Government departments, as honorary superintedents of observatories and in other capacities, help in the meteorological work ; the Posts and Telegraphs Department assists in every way in the rapid transmission of meteorological information ; at the same time they allow their employees to act as observers. The Indo-European Telegraph Department, also, by giving free transit to the daily messages from the Persian observatories, places a large amount of most useful information at the disposal of the Meteorological Department. Weekly telegrams were received from April to September from the Director, Royal Alfred Observatory, Mauritius and from April to October from the departmental observatories at Zanzibar and Seychelles. These telegrams gave valuable information of the weather

conditions in the Indian Ocean and the department is indebted to the officers indicated for the punctual transmission of the information. Thanks are especially due to the Director of the Royal Alfred Observatory for his courtesy in placing the meteorological data of that observatory at our disposal.

The department is greatly indebted for important information about meteorological conditions prevailing before and during the south-west monsoon to the Controller, Physical Department, Cairo; the Directors of the Observatories at Buenos Ayres, Santiago and Batavia; the Astronomer Royal, Cape Town; Director, L'Observatoire Physique Central, Leningrad; M. Thorkell Thorkelsson, Loggildingarstofan, Reykjavik, Iceland; the Secretary, Friends' Industrial Mission, Banani Pemba, Zanzibar; the Principal Medical Officer, Tanganyika Territory, Dar-es-Salam; the Commonwealth Meteorologist, Melbourne, and to the various officers around the Indian frontiers who have collected and supplied valuable snowfall information.

The thanks of the Department are also due to Mr. A. J. Bamford, Superintendent, Colombo Observatory for the very useful help he has rendered from time to time in connection with storm warning work.

SIMLA;
The 12th June 1924.

GILBERT T. WALKER,
Director-General of Observatories.

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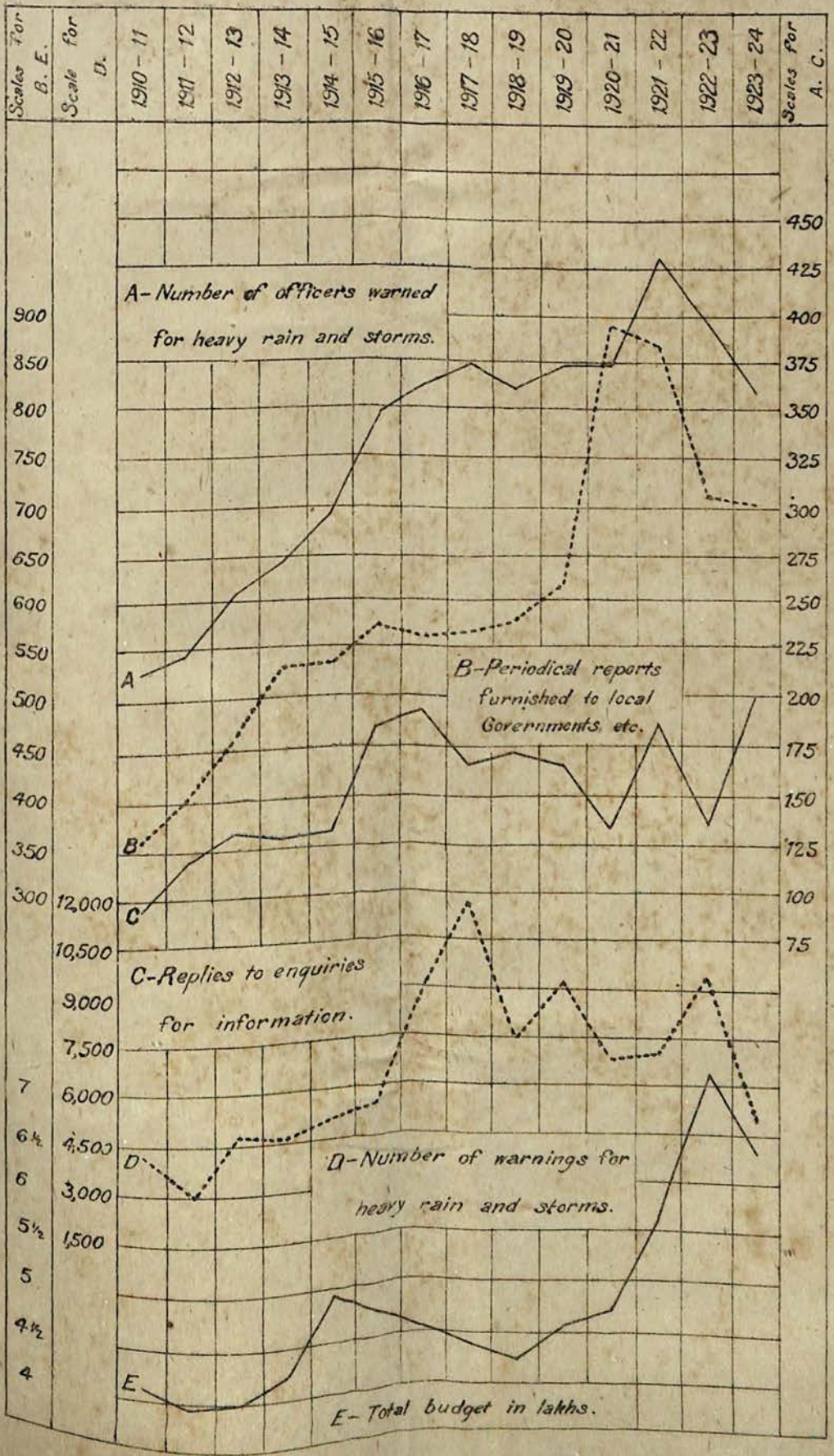
GROWTH IN ACTIVITY AND COST



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Administration Report of the India Meteorological Department for the year 1924-25 and A History of the Department during the half century 1875-1924

SIMLA
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1925

METEOROLOGICAL DEPARTMENT, HALF-CENTENARY, 1925.

DIRECTORS-GENERAL OF INDIAN OBSERVATORIES.

H. F. BLANFORD, Esq., F.R.S.,
1875-1889.

SIR JOHN ELIOT, K.C.I.E., F.R.S.,
1889-1903.

SIR GILBERT WALKER, C.S.I., F.R.S.,
1904-1924.

Report on the Administration of the Meteorological Department of the Government of India in 1924-25, and a General Survey of half a century's Work since the Establishment of the Department.

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THIS is the fiftieth Administration Report of the India Meteorological Department and records the completion of the first half century of systematic observations on weather in India, by uniform methods. It would have been pleasant to have been able to call 1925 a Jubilee year, but that would imply not only a 50 years' course of work, but a prosperous condition of the department at its close, with adequate staff and resources: it will be safer to call this year the half-centenary, and regard it as a fitting time to review the progress made, to take stock of the present and consider the future.

HISTORY.

2. In a country where extremes of climate—temperature, dryness and torrential rainfall—have always added to the difficulties of life, there must often have been a natural instinct to set up a collection of private meteorological instruments and take at least occasional readings. Even in the earliest days of British interest in India this was evidenced, for among the less unsystematic work of this kind there have been records by Colonel Pearse in Calcutta, 1785, and by other officers sprinkled about the country. But the difference is radical between any collection of short series of unordered observations and the work of a centrally controlled system on uniform lines, so that although before 1865 provincial authorities occasionally issued instructions to district administrative and medical officers to note temperatures, rainfall and air pressure, these old observations as actually taken have since been found to be of little value.

Sets of instruments were then issued, but without previous comparison with standards for determination of their errors, and commonly without instructions

for the guidance of observers. Little was known in those days of correct methods of exposing thermometers, and the instruments were frequently hung in rooms of public buildings or placed against the walls of verandahs, convenience for the observer and security from unofficial curiosity having been regarded, perhaps, as the main conditions to be satisfied; comparatively seldom were the thermometers located in open-sided sheds, where they could indicate more correctly the temperature of the open air. Sheristadars, writers, compounders or hospital assistants were told off to take the observations, and being generally untrained, realised no need for accuracy or punctuality. Little attempt apparently was made to turn the data to account, or even to ascertain whether they were of any scientific value. They were, as a rule, forwarded to the Boards of Revenue or Medical Boards in the Presidencies, where they were allowed to accumulate without examination, and remained practically inaccessible for the purposes of scientific enquiry. During the years of the Sepoy Mutiny (1857 to 1860) the collection of meteorological statistics naturally ceased over nearly the whole of India, even at those stations in which rainfall observations then went back some 10, 20 or 30 years.

In these general circumstances it was natural that the records should later be regarded with suspicion, and when ultimately they were examined by Mr. H. F. Blanford, this suspicion was found to be well grounded. Many of the records were at that time in the hands of the Messrs. Von Schlagintweit, who had been sent out by the English Government in 1861, at the instance of Prince Albert, on a scientific mission to India and High Asia. An application for the return of the registers was practically declined except on monetary conditions which were held to be unreasonable. But so important was it considered to examine the records that eventually Blanford, while on furlough in Europe, took the opportunity to visit Munich, went through the registers and obtained copies of parts of them. In the result it seemed to him certain that the meteorological observations taken during this early period at sadar and other stations in obedience to orders from Revenue or Medical Boards and any discussions based on them, were of little or no value from the scientific point of view, however interesting they might be historically in throwing more light upon the meteorological conditions accompanying the droughts and famines of the years 1837-38, 1853-54 and 1865-67 in India.

3. Fortunately, however, observations of very great value were recorded at a few observatories of the first rank, established, chiefly by the East India Company, for purely scientific purposes. Thus, the Madras Astronomical Observatory, which was built and started in 1792, began meteorological observations in 1796, and from that date to the present time a continuous series of observations is available, though only a part has been published. The Colaba Observatory, projected about 1821 for astronomical and other purposes, had its building completed in 1826, but did not begin meteorological work until 1841. The observations were apparently unsatisfactory; for the Government of Bombay in 1864 appointed a committee of enquiry to determine what improvements were needed and, as a result, obtained new magnetic and meteorological instruments and appointed a qualified Director to ensure continuous critical examination and discussion of the data, and frequent publication of the results. This was followed by the creation of a meteorological office for the Bombay Government in 1875, and by the printing of a daily weather report for western India from 1889. The Bombay Observatory, which was till 1898 under the control of the local Government, was placed under the Director-General of Observatories in that year, while both the observatory and the meteorological office were amalgamated under a meteorologist in 1923. The East India Company also had accurate meteorological observations taken from 1847 to 1855 by a trained observer on the summit of Dodabetta, a high peak near Ootacamund.

The Trivandrum Observatory owed its origin in 1836 to the enlightened interest of His Highness Rama Vurmah, the then reigning Raja of Travancore. Meteorological observations began there in 1842, were carried on with increased activity from 1852 to 1864 and, though then threatened with complete stoppage, have in fact continued with more or less regularity up to the present time. In Calcutta an observatory was maintained from 1853 in the compound of the Survey Office buildings in Park Street, where observations were recorded until the completion of Alipore Observatory in 1875.

4. In 1857, Sir Richard Strachey called the attention of the Asiatic Society of Bengal to the uselessness of the desultory attempts that had, up to that time, been made to acquire a knowledge of Indian meteorology, and to the urgent need of a controlling authority capable of directing and utilising the work of observers in India. A committee was accordingly appointed with this object, but shortly afterwards came the outbreak of the Mutiny, when men had little leisure or taste for scientific pursuits. Further consideration of improvement in scientific work remained in abeyance for 5 years, and it was not until 1862 that the Committee drew up a report to Government, and were asked in reply to formulate a scheme for giving practical effect to their recommendations.

HENRY FRANCIS BLANFORD: Bengal Reporter, 1867-74.

Various delays supervened, and, meanwhile, Mr. H. F. Blanford who, after 7 years' service in the Geological Department, had been appointed Professor of Science in the Presidency College, Calcutta, became in 1864 one of the honorary secretaries of the Asiatic Society and in this connection had his attention directed to Meteorology. He was partly responsible for the report drawn up by the Society and laid before Government in the beginning of 1865.

Almost simultaneously Government were pressed on other sides to take action. In October 1864 Calcutta was visited by one of the most destructive cyclones on record; a storm-wave rushed up the Hooghly River and flooded the neighbouring lowlands; upwards of 80,000 human beings were drowned or died of exposure, and a great part of the shipping in the river was wrecked. This cyclone was followed within few weeks by another, which passed over Masulipatam, and the storm wave again cost the lives of about 40,000 persons. The attention of the mercantile and shipping community was naturally aroused, and the Bengal Chamber of Commerce called the attention of Government to the inefficiency of a system under which no warning was given to ships of the approach of one of the most disastrous storms on record. About the same time the Secretary of State for India urged upon Government the necessity of a systematic record of meteorological phenomena in order to furnish data for the investigation of the relations of climate and weather with disease in India, and the further necessity to collect data of value for sanitary improvements and projects. To the Sanitary Commission, then appointed, was referred the whole question of meteorological enquiry in India; and in accordance with its recommendations, provincial meteorological systems were established in the Punjab and North-West Provinces in 1865, Madras in 1866, Bengal in 1867, the Central Provinces in 1868 and in Bombay in 1871. The Bengal meteorological department was established with a twofold purpose, to give cyclone warnings for the protection of shipping and to collect and record systematic meteorological observations throughout the Presidency. Blanford became the Meteorological Reporter of Bengal, while still retaining his professorship in the Presidency College. In his admirable hands the new department at once took a very high position and became known for the accuracy of its data and the thoroughness of its work, while his annual reports on the meteorology of Bengal increased in importance from year to year. Blanford also published, during the eight years for which he held the post of Reporter, a

series of original papers in the publications of the Asiatic Society of Bengal and the Royal Society of London. In one of the latter papers "The Winds of Northern India" he was able, by the use of data collected in Bengal, the North-West Provinces and the Punjab, to recognize the causes of the prevailing air-currents of northern India, and to detect the general relations of the two seasonal monsoons to each other and to the temperature conditions of the country. This paper was particularly valuable, for not only was it the first attempt to discuss this important question by the aid of fairly accurate data, but it was also the earliest essay on Indian meteorology as a whole; and the subject was, for the first time, treated as a problem of dynamic meteorology.

5. While the new system was thus being developed with such success in Bengal, less progress was made elsewhere, and no attempt was made to begin systematic observations in Burma or the native states of India. In fact, the result of the efforts of Government during this decade—1865 to 1874—was to cover and deal with only about one-third of the total area of India, and that by means of 5 entirely independent organisations of work. There was no attempt to co-ordinate the separate systems, nor unity of aim and direction. This parochial system of dealing with the meteorology of a well-defined meteorological area like the Indian monsoon region, though a valuable innovation on past want of foresight, was self-condemned from the first. The commission of enquiry into the Orissa and Bengal famine in 1866 even urged that Professor Tyndall should be invited to come to India to develop meteorological enquiry. After prolonged consideration by the Government of India and the Secretary of State, it was finally determined to reorganise and extend the work of meteorological observation, and to engage a Meteorological Reporter to consolidate the organisation for the whole of India. This appointment was offered to Blanford, and his preparatory report and scheme, in July 1875, form virtually the foundation of the present system of meteorological work in India. The chief object of his proposals was the systematic study of the climate and weather of India as a whole, and the application of the knowledge thus acquired to the issue of storm and other warnings and daily weather forecasts; and subsequent history shows how fully these aims were kept in view and how well they were achieved. The whole of the proposals were approved and sanctioned by Government: and the evolution of the new organisation from those of provincial departments took place smoothly and without hiatus in the work of observation as previously established. While local meteorological reporters were retained in Bengal, the North-West Provinces, the Punjab and Madras, and a further reporter was appointed for Bombay and Rajputana, each was now subordinate to the Imperial Reporter. The chief improvements lay in the adoption of uniform methods of observation, the collection and discussion of all data at a central headquarters and the establishment of a central observatory at Calcutta, which made possible the comparison with standards of every instrument used by the department. The number of observatories was increased immediately from 77 to 94, special attention being paid to filling as far as possible the larger gaps in the net-work of the observing stations over the land area. A preliminary essay in the preparation of daily weather reports was made in 1877, when the Meteorological Office in Calcutta began to collect reports daily by post from all observatories, and to chart all barometric, wind, temperature and rainfall data on daily charts. A study of these soon threw considerable light on the sequence of day-to-day changes in the weather situation, and also proved of high value in enabling the reporter to exercise a close and strict supervision over the daily work of each observer. But as ten days or a fortnight necessarily elapsed before the information was brought

H. F. BLANFORD: Imperial Reporter, 1875-89.

together, the system still lacked the power to give current information to the public or to serve for daily forecast purposes. As a conscious step towards the transmission of weather reports daily by telegraph the new departure was important, and a further stage was soon reached. After the droughts and famines of 1876 and 1877, Government's anxiety for the earliest possible information about the progress of the monsoon of 1878 led, in June of that year, to the institution of the Indian Daily Weather Report for which the 10 A. M. observations, 51 in all, were gathered by telegraph. The printed report was circulated to Government officials in Simla each following morning. This service, as originally sanctioned, was to terminate at the end of the rainy season, but it was found to be of such value that it received various temporary extensions, until in 1881 its permanent establishment was sanctioned in an improved and still more useful form. The improvements were intended partly to give effect to the recommendations of the Madras Famine Commission of 1881, which also prompted various fresh activities, among them the institution of the daily weather telegraphic summary, still circulated from Simla each day throughout the country; the collection at Calcutta and Bombay of current information on weather in the Indian seas as gathered from ships' logs, and the working out of a valuable series of observations collected by the English Meteorological Office from vessels sailing in Indian Seas and made over to the Indian Meteorological Department for discussion. These additional duties necessitated further staff, and a new officer, Mr. Dallas, was recruited from London mainly to reduce and discuss the marine observations, which were later embodied in monthly weather charts of the Bay of Bengal and of the Arabian Sea for the benefit of shipping. A few years later the first Indian officer of the department was appointed and trained to prepare the daily weather reports.

6. Meanwhile improvements were also being effected in the work of the provincial offices. A storm signal service was established for the Bombay coast in 1880; extensions were made in the Calcutta storm-signal service in 1881: and from 1883 two Daily Weather Reports, one for the Bay of Bengal and the other for the Presidency, were published regularly by the Bengal Reporter.

A fresh duty of practical value devolved upon the central office in 1885. This resulted from the destructive floods in the lower valleys of the Nerbudda and Tapti rivers in July of the previous year, of which the district officers received no warning in the absence of any organization to that end. The floods in these rivers, it may be noted, are usually the result of excessive rainfall accompanying the passage of cyclonic depressions in their westerly course from the Bay of Bengal. It is almost always possible to send ample premonitary advice of their approach, while immediate notice of actual heavy rain in the catchment areas also serves later as a warning for floods in the lower reaches of the rivers. Telegraphic warnings of probable and actual heavy rainfall to the district officers and political officers of Surat, Baroda, etc., were therefore arranged for in that year, and have continued ever since.

At this stage also, the first of the long and continous series of Indian Monsoon forecasts was issued and published in the *Gazette of India*. Previously, tentative forecasts had been made by Wilson in 1874, by Eliot in June 1878 and by Blanford in 1882 to 1884. In 1885 the indications on which Blanford's forecast was based were more pronounced than in either of the preceding years, and the prediction which they seemed to justify, that the influx of the monsoon rains on the west coast and in southern and western India, generally, would be considerably retarded, was so fully borne out by the subsequent history of the season that confidence in the general validity of the method was much strengthened. The basis of the forecast was the connection which Blanford has discovered between snowfall on the Himalayas

and the incidence of the monsoon, a connection of sufficient interest to form the subject of a valuable paper by Blanford in the Proceedings of the Royal Society of London.

7. Blanford's most important work at this time was undoubtedly the series of annual reports on the meteorology of India (from 1876 to 1885), but he was also contributing many scientific papers to the departmental memoirs and other publications. The subjects of these papers show how largely his mind was occupied with the regular diurnal and annual meteorological changes in India. He considered that a full knowledge of these matters was of primary importance at that stage of development, and would throw valuable light on some of the most important features of Indian weather. He had at an earlier date written and published the "Indian Meteorologist's Vade Mecum", which was particularly intended to inform Indian observers what and how they were to observe. In order, however, to arouse an intelligent interest in their work, Blanford added, in Part II of that book, a most readable account of all the chief features of Indian meteorology so far as they were then known, with explanations based on the ideas of recent advances in physical science. The "Vade Mecum" was, indeed, practically the first treatise to place the ideas of the modern school of dynamical meteorology in an easily accessible form before ordinary readers. It was for many years the best book on modern meteorology, and was the forerunner of the numerous treatises on the science which have been published in the United States, Germany, and England. Blanford's last and most important work of investigation was the monograph on "The rainfall of India", published in the Memoirs of the India Meteorological Department. It was the outcome of years of labour spent in obtaining all the available data, and sifting out the doubtful from the trustworthy. The result of this investigation was to secure an accurate knowledge of all the broader features of the distribution of rainfall in India, and of the chief factors determining the law of that distribution.

Blanford left India on long leave in 1887 and retired on pension in 1889; but despite failing health, he continued, until his death in 1893, to devote himself with unwearied zeal to the discussion of problems in this his favourite subject. He presented, shortly before his death the chief results of his own and his co-workers' investigations to the English-reading public, in his very interesting book 'Climates and weather of India'. European meteorologists recognised almost from the first the great value of Blanford's papers and the high level of his scientific work: and his name will always be associated with the beginnings and development of scientific meteorology in India, while the rapid rise of the department under him furnishes eloquent testimony to his sound judgment, zeal and untiring energy.

JOHN ELIOT: Imperial Reporter, 1889-1903.

8. John Eliot, who had been Blanford's successor in the professorship of Science in Calcutta and in the post of Meteorological Reporter to the Government of Bengal, now succeeded also to the Imperial post. He had already acted in the appointment on one or two occasions, and had been largely responsible for extensions in the Bengal meteorological system. His investigations into cyclones in the Bay of Bengal were well-known. In one of the earliest of these, a "Report on the Vizagapatam and Backergunj Cyclones of October 1876", in which latter cyclone about two hundred thousand people were drowned in a single half hour by a huge storm wave sweeping over the Island of Sandip, Eliot largely developed and extended the theory of the formation of cyclones. The publication excited unusual attention both in India and England; so much so, indeed, that a request was made in the House of Commons for the report to be produced and laid on the table. In connection,

also with his study of cyclones, Eliot had started the systematic collection in India of weather observations made by ships in the Indian Seas.

The pioneer stages in the development of the department on an imperial basis were by that time complete and Eliot was able to make rapid progress in consolidating the position and applying to practical ends the knowledge already gained. One of the first changes was the adoption of 8 A. M. in place of 10 A. M. as the hour for observations to be sent by telegram to Simla, Calcutta and Bombay, and by this change the publication of all daily weather reports was correspondingly accelerated. He discontinued in 1889 the 10 and 16 hrs. observations at 88 stations where careless work or imperfect instruments had been vitiating previous records; and thereafter these fuller records were maintained at only 69 stations where examination indicated the returns to be accurate and to form a reliable basis for scientific discussion in the annual report.

Important improvements were now effected in the methods of rainfall registration. Before 1887 the records of only 497 rainfall stations were received by the Imperial Government, while those maintained for Provincial Governments, totalled 1,390. Further, the measurements at these stations had been started provincially under the revenue authorities, and had never been systematised for India as a whole; so that there resulted a lack of uniformity in the hours and methods of observation as well as in the publication of results. A striking instance of the difficulty and inconvenience of dealing with unsystematised observations had cropped up earlier in connection with a question about the influence of forests upon rainfall. The rainfall statistics of the Central Provinces for the previous 20 years, if they could have been accepted as true, would have established most conclusively that the extension of forests had been accompanied by a marked increase in the average rainfall of the forest districts. But when Blanford made further enquiry into the value of these rainfall returns, the Chief Commissioner for the Central Provinces had to acknowledge that uncertainties about the gauges used in past years, and inaccuracies in registration, made the records quite unreliable. Unsystematic registration thus postponed a decision about the influence of forests on rainfall until, some 20 years later, the question was again tackled with records of undoubted value.

A uniform system of registration, inspection and publication was now introduced throughout India; all gauges had to be of standard pattern and were tested by the Meteorological Department before issue. Further, uniformity in method of publication by provincial Governments enabled the Meteorological Department to collect the rainfall data for the whole of India in annual volumes which have been of great service to irrigation and other engineers and sanitary officers, as well as to meteorologists throughout the world.

9. Up to this time no effort had been made to secure the co-operation of the larger Native States in meteorological work. Eliot visited Hyderabad in 1890 for that purpose and his suggestions received a ready response from His Exalted Highness the Nizam's Government, which established seven observatories within a year. The Mysore State also arranged about the same time to establish a local battery of stations. A first-class observatory, supplied with photographic self-registering instruments, was established at Bangalore, and smaller observatories at three other stations. A few years later the Kashmir Durbar cordially agreed to the establishment of four observatories, in addition to that at Srinagar, and these have furnished most valuable observations for an area where meteorology presents many unique features. The net-work of reporting stations was also extended in Upper Burma and into Persia. The Persian observatories were founded in the expectation, since completely

substantiated, that they would throw light upon the origin and march of the cold-weather depressions which bring winter rainfall to northern India and snowfall to the Himalayas.

The issue of a daily weather report in Bombay, the need of which had for long been pressed by the commercial public there and was prominently suggested during the enquiry into the loss of the Shepherds' steamer *Vaitarna*, was made feasible in 1889 by considerable annual contributions from the Chamber of Commerce and the Port Trust to cover part of the actual increased expenditure for staff. Four years later the unsatisfactory seasons and partial failures of the crops of 1892 and 1893 in the Madras Presidency quickened the interest of the Madras authorities and public in the subject of daily weather reports, and both the Government and the press expressed dissatisfaction with the meagre published statement on rainfall and weather in Madras, which was all that could be incorporated in the daily telegraphic summaries issued from Simla. The result was the institution from October 1893 of a Madras daily weather report, similar to those of Calcutta and Bombay.

Another series of published daily weather charts began in this year and was continued till 1899. In these was embodied information from the whole Indian Monsoon area, including land observations from India, Burma, Persia, Arabia, and several islands such as the Seychelles, with ships' observations for all parts of the Indian Ocean to the north of latitude 12° S. While found to be of considerable use to shipping firms and mariners, these charts were intended mainly for the study by meteorologists of the relations between the weather of India and that of the adjacent seas, and they have furnished important information regarding the advance of the great monsoon currents from the equatorial belt to their goal in north India, as well as of the conditions at sea which are followed by "breaks" in the rains inland. Though publication ceased in 1899, the charts themselves were continued till 1904 for the internal use of the department.

Various improvements were made at different times in the storm signal systems (one in 1888 on the recommendation of the Court of Enquiry on the loss of the S. S. Sir John Lawrence), and ultimately in 1898 a single uniform system of signals was adopted at all the major Indian ports; from this system, which was rather too extensive and complicated for small ports and fishing towns, a set of three signals (modified since into the present "brief system") was chosen, as adequate for these smaller ports needing warnings only of storms likely to affect them directly. The efficiency of the storm-warning service was increased in 1896 by more rapid transmission of all telegraphic weather messages, special priority being then accorded to "storm" messages.

A large extension of the flood warning system was called for as a result of a remarkable series of floods during the southwest monsoon of 1889. The Public Works Department issued a circular to all its officers, as a result of which there was received a large number of applications for information of heavy rainfall and warnings of floods, chiefly in upper India. The flood warning system has continued further to expand until there are now some 200 officers, or more, on the warning lists.

Seismological observations by Milne instruments were begun at the major observatories in 1898 at the request of the Earthquake Committee of the British Association.

Eliot was greatly interested in the subject of solar physics and was instrumental in starting the Solar Physics Observatory at Kodaikanal, which in recent years, under the able directorship of Mr. Evershed, has contributed so largely to our knowledge of the 'meteorology' of the sun.

10. On the purely scientfic side also Eliot was an indefatigable worker and contributed largely to the furtherance of the science of weather. During his connection with the Department he wrote no less than 50 original papers on various meteorological subjects. His early researches, as mentioned above, were largely concerned with extending our knowledge of the origin and progress of cyclones in the Bay of Bengal. The results of these investigations were embodied in a handbook which dealt in a comprehensive manner with the various features of these storms. The book was greatly read by mariners, went through two editions and has in all probability been the mean of saving many vessels—possibly from destruction and certainly from damage— by enabling their navigators to avoid the more dangerous parts of these cyclones. Of his later papers, possibly those on (*a*) the cold-weather storms of northern India, (*b*) oscillatory changes of long period and of short period in India, and (*c*) the hourly observations recorded at 29 stations, were the most important. The first of these discussed in an exhaustive manner the varying characteristics of the cold-weather storms and associated phenomena, and was described in "Nature" as "a model of scientific investigation". An interesting result of this research was the outline of a method, and the beginning of the practice, of forecasting the winter rains. The connection then found between the winter rains and certain previous barometric measurements (technically known as the vertical pressure anomalies) had been found, by an examination of available data, to hold good in four years out of five; but this relationship has not been confirmed by later experience. The second memoir indicated and discussed some possible methods of seasonal forecasting, while the third investigated the relations of the diurnal variations of the air pressure with those of other meteorological elements, and showed how far seasonal and local geographical conditions modify the amplitudes and periods of the diurnal oscillation.

11. Eliot's strenuous efforts to increase, as far as possible, the efficiency and usefulness of the department had thus met with considerable success, and had brought it into line with the best of meteorological organisations in other countries. He retired from service at the end of 1903 and was gazetted K.C.I.E. in that year.

After his retirement he was able to see through the press his last publication and the most valuable of all his works, "The Climatological Atlas of India," which a European review described as "a unique storehouse of the climatology of a great unit of tropical land, a magnificent acquisition, a very mine of meteorological relationships, for which we cannot be too grateful to the enlightenment of the Indian Government and the patient labour of Sir John Eliot and his assistants." Unhappily Sir John Elliot's death in 1908 prevented the completion of the "Handbook of Indian Meteorology" which he had planned as a companion volume to the Atlas.

GILBERT THOMAS WALKER, Director-General of Observatories, 1904—1924.

12. Gilbert Thomas Walker, Fellow and mathematical lecturer of Trinity College, Cambridge, and Senior Wrangler in the Mathematical Tripos of 1889, succeeded Sir John Eliot on the 1st January 1904 as head of the department. In England Sir Gilbert's original work had been almost entirely in two fields, dynamics and electro-magnetism. His papers on *The Motion of Elongated Projectiles* (Proc. Roy. Artill. Inst. 1892), on Dynamical Tops (Quart. Journ. Math. 1896) and his paper *On Boomerangs* (Phil. Trans., Royal Society), had given him the reputation of an authority on this branch of dynamics, and led to his being invited to write the article "Spiel und Sport" for the great Encyklopädie der Math. Wissenschaften. His electrical papers began with a substantial memoir *Repulsion and Rotation produced by Alternating Electric Currents* occupying 50 pages of the Phil. Trans., Royal Society, for 1892. In 1900 he was awarded the Adams Prize by the University of Cambridge for an essay on *Aberration and sam*

other problems connected with the electromagnetic field, which was published later in book form ; this was followed by a paper in the *Camb. Phil., Trans.* of 1901 *Some Problems in Electric Convection* and one on *The Optical properties of thin metal plates* in the *Annalen der Physik for 1903.*

Shortly after Sir Gilbert assumed charge of the department, the Secretary of State decided that the scientific activities should be widened and the staff increased. In place of one meteorologist at Simla and a second at Calcutta there were, from the beginning of 1905, three such officers at Simla. With this increased staff a more careful and critical examination of all telegraphic observations became possible, and soon led to considerable improvements both in the accuracy of the work of the ordinary observers and in the condition of the observatories. While the production of the Indian Daily Weather Report was thus accelerated, the telegraphic summary was made the chief mode of publication ; it is now issued at noon as an urgent press message, to be posted up at telegraph offices in all the large towns of India, and is delivered as a telegram to subscribers of Rs. 10 monthly, now numbering some 90 or more in the monsoon season.

Changes were made in the routine work connected with the study of marine meteorology. It had been the practice to issue each month pilot charts of the Indian Seas, showing the mean pressure, wind and surface ocean currents as far beyond the equator as 12° S., and about 160 copies were commonly sold at 4 annas each. It was now decided to bind these monthly charts once for all in atlas form, with additional charts illustrating historical storm tracks in the several months, and some selected actual storms in detail ; and Messrs. Bartholomew of Edinburgh undertook production. On publication in 1908 the atlas appeared to be greatly appreciated by the shipping community.

It has previously been mentioned that routine charts of the whole monsoon area, land and sea down to 12°, were drawn up daily from 1893 to 1904 by using observations extracted from logs of ocean-going ships. In the latter year it was felt that an attempt should be made to extend the area down, if possible, to the Kerguelen Islands, or in any case to include the far southern high pressure region where monsoon winds might originate. The meteorological offices in London, Hamburg and Mauritius were already collecting logs from many ships sailing through those regions, and arrangements were accordingly made for copies of the logs to be sent to India. To make use of this material, it was necessary to try weekly means instead of daily observations, as parts of the regions dealt with were but sparsely crossed by ships ; this practice continued with poor results till 1906 when improvement was sought by adopting monthly means. An essential feature of the charts was to be the pressure distribution, and it is well known that ships' readings of the barometer tend to be bad unless a close touch with ships' officers can be maintained, and interest in accuracy induced. Such ' touch ' was necessarily absent with the weakness of meteorological staff ; and in the result this work, with all its potential usefulness in seasonal forecasting, had to be relinquished.

13. At about this time there was a rapid growth in the departmental correspondence. Requests for information of a general or statistical character began to come in from officers interested in the relation of weather and disease, weather and agriculture, and such other practical matters, as well as from firms wishing to start factories under special conditions ; while enquiries about meteorological subjects, books, instruments and methods of observation became very numerous. The work involved in answering such questions is sometimes very considerable.

As a result of the great Dharamsala earthquake, the seismographs which had been put up at major observatories in 1898 were supplemented in 1905 in Simla by an Omori-Ewing instrument loaned by Professor Omori ; and subsequently others

of this type were obtained and set up in Colaba, Calcutta and Simla. Schedules of all instrumental measurements have since then been supplied regularly to the Seismological Committee of the British Association, and a systematic collection of notes on earthquakes, as felt by observers in India, has been made for the Geological Survey of India.

Original investigations were now begun on various new problems, and many of them were dealt with by Sir Gilbert himself. An account of these is given below as a review of his contributions to meteorological knowledge.

Research work was undertaken on the experimental side of meteorology. A small laboratory and workshop had been provided in Simla, and two mechanics were regularly employed. Dr. Simpson investigated the electric potential gradient in Simla and carried on systematic observations on the electricity of rainfall, which led to valuable results. For he found the long-sought cause of thunderstorm formation, and showed that it lay in the breaking up of drops of rain carried upwards by air currents, and the consequent formation of a strong positive charge on the rain, with a negative charge in the air. His memoir on this subject (Indian Meterological Memoirs, Vol. XX, part 8) is now regarded the world over as a classic.

14. A beginning was now made on meteorological measurements in the upper air. As early as 1877, H. F. Blanford had clearly recognised the need of enlarging the scope of measurement by freely employing small observation balloons, and had published his view that with such means in India, a few years would suffice to place our knowledge of meteorological laws on a very advanced footing. For this work he considered India to be the one country in the world most suitable; the northern boundary of the high Himalayas, and the southern boundary of flat and unvarying barometric pressure in the equatorial zone forming almost impassable meteorological limits to the immense range of 30° of latitude under a nearly vertical sun.

Later, his successor, Sir John Eliot expressed similar views on the necessity to undertake such work, and indeed was instrumental at his retirement in making provision for this object. A very strong advocate was C. Little, the official meteorologist in Bengal, who in a series of papers in the Journal of the Asiatic Society of Bengal, 1903-04, insisted with the greatest vigour on the immediate need to work with balloons, and elaborated his reasoning for attributing the want of departmental success in seasonal forecasts to the practical neglect of what Blanford had laid down 20 years earlier as a *sine qua non*. Little himself had sent up some small balloons in Calcutta, and had at once found them helpful in verifying points on air circulation in Bengal, to account for weather variations.

In 1905, then, such work was definitely begun, though as yet without any allocation of funds for systematic study. A kite-wire winding machine and kites of various shapes were made, and first tested in action during August and September 1905 at Karachi. Their purpose was to lift recording meteorographs, light instruments which registered on a diagram the varying pressure, temperature and humidity of all the air layers they passed through. They were either fixed within the kite itself, or made to run up and down the kite wire during the flight. The kites were used again the following year at Belgaum during May and August, when information was obtained of the air conditions in the Peninsula previous to and during the monsoon, from the ground level up to a height of 11,000 feet above the sea. Similar observations were made at Belgaum in the monsoon of 1907, and from a ship in the Bay of Bengal and the Arabian Sea in August and September 1907.

Another type of light recording instrument for attachment to free ballons was copied by Indian mechanics, with minor changes, from the excellent model developed in England by Mr. W. H. Dines. The class of recorder which had been used till

then in Europe was a comparatively heavy and very expensive instrument, unsuitable for use in India where a large proportion of total losses was expected; the light Dines' model was then the only one that could be made at a cost to suit this country. In a first trial of these in September and October 1908, in Jhang (Punjab), 11 were recovered out of 17 released. All but one contained good records, the greatest height reached being 65,000 feet above sea level; and there were in three cases thought to be signs, perhaps a little doubtful, that the strange upper region of constant temperature, found first in Europe and now looked for in India, was penetrated three times. In the following year, 17 balloons with instruments were liberated at Jhang during the monsoon months, June and July, and 7 in December; of the first set more than half were recovered, but only one of those in December. The heights reached during the monsoon ranged up to 12 miles, with a lowest temperature of about —107°F. and the descents occurred at short distances from Jhang, in several cases within 10 miles of the starting point. The balloons in December all travelled eastward, and their horizontal velocities indicated very strong winds a few miles above the gound surface. The one instrument recovered had only reached the 6 mile level, with a lowest temperature of —35°F., but it came down as far away as Lahore. With the knowledge which we now possess of the strong upper-air winds in the cold weather, we may be certain that the remaining instruments were carried into the Himalayas or Tibet, and that, but for some defect in the balloon which touched ground in Lahore, no one of the seven instruments would have been heard of again.

A feature of the ascents in the monsoon was the liberation on two occasions of a pair of instruments together on the same balloon, in order to contrast the records of an associated couple and ascertain to how great an extent the traces could be relied upon to represent actual conditions. This question had assumed some importance in consequence of doubts which had been expressed by scientists at home as to the capabilities of instruments constructed so lightly as these must necessarily be. One pair was recovered, and the two independent records were found to agree as well as could reasonably be expected.

15. All these were preliminary essays in upper-air work, the funds available having been inadequate for any serious tackling of the problems in view. But in 1912, on the insistence of the Secretary of State, to whom the Royal Society had sent a protest on the department's lack of means, a real, if small, allotment was definitely made, and very rapidly used to build and start Agra Upper-air Observatory, and begin work there and at several outstations, with observation and instrument-carrying balloons. Electrical plant was put down for the making of hydrogen, and its compression into cylinders for transport about country, and has been kept working continuously since. The greater part of the observational work has been on free pilot balloons, of 2′ or 3′ diameter, watched by measuring theodolites, and a very great deal of useful information has by now been gathered as to the prevailing currents at all heights up to 30,000′, and in all seasons, over the northern half of India and at one station, Bangalore, in S. India by the valued assistance of the Government of Mysore. Some thousands of these simple observation balloons have been made and sent up, and this work has already gone a long way towards establishing definite normals of wind data, and showing reasons, not observable at ground levels, for the character of coming winter rains, of breaks in the monsoon rains, and even (though at present to a less extent) of the character of a coming southwest monsoon. The daily results up to 20,000′ are telegraphed to Simla from 7 selected stations, and much used in daily weather forecasting. The memoirs that have been published on this work (I. M. M., Vol. 20, parts 1, 2, 7; Vol. 22, parts 4, 5; Vol. 23, part 3; Vol. 24, parts 5, 6, 7, 8) will give an idea of how earnestly the

small facilities available have been used, and how fruitful have been the immediate results. A critical review in " Nature " (Sept. 1924) of the later ones of this series of memoirs ended with the remark :—

> " Dr. Harwood finds a very noticeable coincidence between the track of storms and depressions, as shown in the Climatological Atlas of India and in the Meteorological Atlas of the Indian Seas, and the monthly mean directions of the upper winds at the cirrus level. If this be more than a coincidence, and it seems to be so, it has an important bearing on the formation and propagation of cyclones, and shows that their source must be sought for in the upper winds rather than in the surface conditions.
>
> The four Memoirs form a very valuable contribution, not to Indian meteorology only, but also to meteorology in general."

It will be seen that a new point is recognised as possibly emerging from this upper-air work, that of the cause and amount of a cyclone's recurving in its destructive course at sea.

A second review of these papers by the American Meteorological Society, in December 1924, draws public attention to the very remarkable results found for temperature distribution in the upper air of the monsoon : in any future method of forecasting the rainfall amount and distribution during the course of a monsoon, it is fairly certain that the essential measurements will be temperature and humidity distribution upwards to some 4 miles height. These measures are so far only being taken systematically at Agra : it remains to extend them to several other stations in India.

16. Reverting now to the period 1905 to 1909, it has been shown that the appointment of new scientific staff was productive of much new knowledge of importance, and that the work of those years set a standard for India in fields of new activities. But unfortunately the maintenance of these promising beginnings was thereafter handicapped for one reason or another, and has continued so right up to the present time. The departure of Dr. Simpson on Scott's South Polar Expedition in 1910 and the subsequent resignation of Mr. Patterson, followed by illness among the remaining officers, led in a period when routine work was with difficulty kept up to date and research work became impossible. Pressure from the financial side then threatened to make the temporary shortness of staff a permanency, and necessitated the cutting down of the routine work to the very lowest limits consistent with efficiency in the principal objects of immediate utility. Observatories were reduced, or abolished wherever possible, and only a barely sufficient network of stations maintained over the country to provide information of the major changes in the weather situation from day to day. The more purely scientific work suffered grievously, and all attempts at improving methods of forecasting and storm warning, or gaining more insight into Indian weather were temporarily abandoned. It seemed, in fact, that any scientific enquiries with the object of improving practical methods would be rendered impossible, and that the work of the department would be confined to the mere supervision and publication of meteorological statistics. Happily, this disaster was averted, and at the overruling instance of the Secretary of State sanction was given in 1912 for a return to the original number of officers' posts and at the same time the systematic scheme of enquiry into the meteorology of the upper-air, which has been briefly described above, was considered and sanctioned. A dole of three lakhs was granted to cover 10 years' work under the charge of two officers whose services were to be devoted entirely to this purpose. The scheme was to be put into operation

in the financial year 1913-14, when the two officers, transferred their headquarters to Agra and began work in the new upper-air observatory there. By the beginning of 1914, therefore, the outlook for the department was again, perhaps, showing some glimmerings of hope. But, no sooner had the staff settled down to the new regime than the Great War called for officers, and the years 1916 to 1919 formed a period in which part of the routine work, *e.g.*, the preparation of Monthly Weather Reviews and Annual Summaries, as well as the examination and compilation of upper air results, had to be allowed to fall into arrears. Practically the only attempt at scientific work, at this time was the engagement of part of the clerical staff on a programme of computation, which Sir Gilbert Walker was later able to utilise in a series of important papers, to be referred to later. In 1920, when some recovery from the effects of the war was hoped for, the department suffered a serious double loss in the death of Rai Bahadur Hem Raj, who possessed a unique knowledge of Indian weather, and in the resignation of Dr. Simpson, who had been appointed Director of the British Meteorological Office under the Air Ministry. In the following year, two more officers resigned, namely, Dr. Harwood, who was offered and accepted a post under the English Meteorological Office, and Mr. Chinmayanandam, who reverted to the Accounts Department. Both of these resignations resulted from dissatisfaction with inadequate pay and prospects. In a scientific department the efficiency of which is so completely dependent on the maintenance of trained staff, these losses were serious and disheartening, and it was with the greatest difficulty at times that the skeleton routine work of the department could be carried on.

17. Hitherto all the gazetted officers of the department had been recruited on personal rates of pay ; there was no cadre of officers on a uniform pay scale as in other services. This was now remedied by the institution of a Meteorological Service, Government at the same time deciding that it should be Indianised as far as possible; and suitable Indian officers were appointed in 1922 to the four existing vacancies. All difficulties were not yet over, however. Financial stringency was by now dictating a policy of retrenchment on all departments of Government and, despite the already restricted activities of the meteorological department, and without regard to the fact that for several years complete collapse had barely been escaped, the department also was instructed to fall into line. Although the main items of expenditure, telegraphic costs and pay of establishment, had been burdened by a doubling of the telegraphic rates and establishment costs since 1914 yet the departmental budget, which stood at 5 lakhs in that earlier year was limited, to 6·2 lakhs in 1923-24. One of the gazetted officers' posts at Kodaikanal was abolished, a proceeding which has imposed on the output of research work from that observatory a restriction which is quite out of proportion to the savings effected. It was possible also to make a few retrenchments in establishment, and by drastic reductions in the free distribution lists of the various weather reports ; but the main curtailment of expenditure had to be effected in telegraphic charges. In consequence the periods of issue of the Calcutta, Bombay and Madras reports were shortened to 10½, 6 and 9 months respectively, and the number of stations reporting daily to Calcutta and Madras was greatly curtailed. Vigorous protests against many of these measures have been made by the Press, and by various associations such as the Chambers of Commerce of Bengal, Bombay, Madras and Narayanganj, the Associated Chambers of Commerce for India and the Association of Marine Insurance Agents. The Committee of Inquiry on the loss of the S. S. " Okara " also criticised the new retrenchment arrangements in so far as they involved the issue of storm warnings for the Bay from Simla instead of from Calcutta. One by one, most of these retrenchments have been found to have been mistakes, and there is now no question that the blind application of general instructions to reduce expenditure, to a department which has always lived at the lower limit of outlay, was a very ill-advised step.

During all this period, 1909 to 1923, comparatively little change except reduction, had taken place in the routine work of the department, and the main new activity lay in research work at the Agra upper-air observatory as outlined above. But one other matter deserves notice. In the years 1913 to 1915, the storm warning service for ports and ships at sea had been thoroughly discussed, and a new uniform and simplified code of signals applicable to all Indian and Burman ports had been introduced. At the same time regular transmission of weather bulletins by wireless to ships at sea was arranged for, and a start was made in the early part of 1914 with the receipt from ships at sea of coded weather messages in the hope that the accuracy of our warnings in the case of storms far out at sea would be improved. This was another line of activities necessarily stopped by the War, but the scheme was taken up again in 1920 and, although the response from ships has not been as frequent as the department would wish, it is steadily increasing and there is every likelihood of a really active co-operation in the near future between the department and the shipping community, which will result in a very efficient warning service.

18. A review of Sir Gilbert Walker's contributions to meteorological knowledge will form a fitting finish to this fifty years' history ; and in view of his recent retirement his work may be dealt with more fully than that of his predecessors.

At the request of Government he prepared a report in January 1908 dealing, on purely meteorological evidence, with the question of supposed changes of climate in India. The comparative weakness of the monsoons in northwest India after 1894 had from time to time given rise to conjectures that the climate in that region had altered permanently, and various hypotheses such as increase of irrigation or diminution of forests had been put forward to account for the change. An analysis of the evidence led Sir Gilbert to the conclusion that the spell of deficient monsoon rain fall in central and northwestern India ought to be attributed to something abnormal in the larger movements of the atmosphere and not to human agency in India ; the deficiency had not lasted long enough to justify a verdict of permanent change of climate ; and there were marked indications of an impending return to good seasons. The years since 1908 have fully supported these conclusions.

Another interesting report was presented to Government in 1910 on the question of the liability to drought in India as compared with other countries.

19. But the main problem which faced him was that which had faced his predecessors—the problem of forecasting the monsoon rain all. He soon noted that the graphical methods which had hitherto been employed for estimating the relationship between monsoon rainfall and other factors were open to objection, because, when disturbing factors are numerous or the connection sought is slight, the same curves may be variously interpreted by different authors. Sir Gilbert therefore brought to bear upon his problem the statistical method of what is known as the " co-efficient of correlation ", a method that gives quantitative instead of merely qualitative results and is free from subjective influences. He also considered it necessary not to limit his enquiries to the Indian monsoon region but to take the whole world for his field of search for correlated factors, and was content to leave for subsequent work any attempts to obtain physical explanations for the relationships that should be found. In 1910 there appeared the first of a series of departmental memoirs on the statistical examination of such relationships. Though barometric pressure in India was found to be strongly correlated contemporaneously with the amount of monsoon rainfall, the connection with Indian pressure in May or in earlier months was found to be very slight. The association with Indian temperature in May was also examined. Since the heating up of the lands of south Asia is a fundamental portion of the mechanism that brings the moisture-bearing winds northward over

the equator to India, it was popularly believed that years of high temperature in May would be years of abundant rain, and *vice versa*. But the data do not confirm any conclusion of the kind, either when the temperatures over India as a whole or when those of the northwestern regions only are considered ; and Sir Gilbert concluded that the paradox might be ascribed to our ignorance of temperatures *in the upper layers of the atmosphere.*

When at a loss for an explanation of failures in the Indian rains, several writers had put forward the suggestion that an abundance of icebergs in the sou h Indian ocean would probably have a marked effect on the sea temperatures and so have a determining influence upon the monsoon. An examination of the information about ice as recorded by ships, did not however support the suggestion. On the other hand, the ice data of the south Atlantic ocean were much more promising, for they emphatically suggested that years of much ice off South America tended to be years of high pressure in the Argentine and Chili and of good rainfall in India.

The origin of monsoon forecasting, as already noted, lay in Blanford's discovery that late and heavy snowfall in the mountains to the north and northwest of India was prejudicial to rainfall in northwest India ; Blanford had also recognised that associated with late snowfall were high pressure in the neighbourhood of Gujarat, and northwesterly winds over northwest India. With the data which had accumulated since Blanford's time, Sir Gilbert was able to subject this question to a critical statistical examination and conclusively showed that the snowfall accumulation at the end of May, and not the amount which actually falls in May, is the important factor. Turning his attention now to extra-Indian factors Sir Gilbert considered that the connections with pressure at Mauritius and rainfall at Zanzibar in May, and with pressure in South America in April and May, were sufficiently pronounced to justify their use, along with the snowfall factor, in a forecast of the monsoon. The relative importance to be attached to each factor was assessed s atistically and expressed in the form of an equation, which could be applied by anyone and was free from personal bias. It was recognised that by no means all the factors affecting the monsoon had been discovered ; other potent factors, unknown and unassessed, might upset the forecasts. All the more interesting therefore was it to find, on examination 13 years later, that the indications given by the 1910 formula had been fairly definite in eight years and been of the right sign in seven of these eight years. In these early memoirs similar methods were applied to determine the relationship of the Nile flood and Australian summer rainfall with other meteorological factors ; and statistical formulæ were given as guides for rough forecasts of these two phenomena.

In later years further progress in the solution of the monsoon problem was made by considering the local distribution of monsoon rainfall. Excessive rain in April and May at Zanzibar, which is close to the path of the Indian monsoon winds, appears to be prejudicial to the rain from the Arabian Sea monsoon ; but, like snowfall, it has no influence on the rains of Burma and N. E. India, which come from the Bay monsoon. Similarly excessive rain at Seychelles in the path of the Bay monsoon is prejudicial to the rainfall brought by that monsoon. Improvements in forecasting were attained by considering Burma, N. E. India and S. Madras separately, and dividing the bulk of India into two areas, the north-west region and the Peninsula, each fairly homogeneous in its dependence on external factors. By 1924 several other important relationships were discovered, notably the favourable effects of low pressure at the Cape in the previous spring months, deficient rainfall in the preceding rainy seasons in Rhodesia and Java, and low winter temperatures in the Aleutian Islands.

The problem of forecasting at the beginning of January the subsequent winter precipitation of northwest India was tackled in a similar manner; the factors ultimately adopted for use for this purpose being the preceding precipitation in northern India, Persia, the Andamans and Zanzibar, and barometric pressure and rain at the Seychelles. In short, before his retirement Sir Gilbert had examined most of the available meteorological data from all corners of the earth for the light they could throw on the Indian monsoon and winter rains; and it is clear that any considerable further improvement in such methods of forecasting must await the tabulation of the rainfall of large areas like Australia, America and Africa and the accumulation of data from Antarctica and the upper air.

20. While the investigation of the relationships between the Indian monsoon rainfall and extra-Indian factors aimed primarily at improving the monsoon forecasts, it also led incidentally to the accumulation of a great deal of information concerning world-wide variations of weather. On collecting these together, since all weather operations may be ascribed ultimately to energy from the sun, it was natural in the first place to consider how far the variations were controlled by variations in numbers of sunspots. In the year 1915 three memoirs were published dealing with the connection of sunspots with rainfall, temperature and pressure all over the earth; and the question of the effect of the sun as a direct control of weather was again reviewed in a paper in 1923. Authorities are agreed that increased spottedness of the sun is generally accompanied by increased solar radiation. It is remarkable therefore that a period of sunspot maximum is accompanied, on the average, by a fall of temperature, particularly in tropical regions. The relationship between sunspots and pressure turned out to be very slight, and not in the same sense for the whole earth, increased spottedness leading on the average to increased pressure over the Western hemisphere and decreased pressure over the Eastern. Rainfall is affected irregularly but in general the relationships of sunspots with rain are opposed to those with pressure. On Indian cloud, sunspots exert apparently a slight stimulation except in the hot weather months, April and May. For the sunspot-temperature relationship a plausible explanation is afforded by supposing sunspots to cause higher temperatures in the upper air over land areas, inducing indraught of sea winds with increased humidity and cloud and so producing a lowering of temperature at lower levels. The increase in humidity, however, would also call for either increased temperature or increased wind velocity over the oceans, and neither of these results appears to be specially associated with sunspot maxima. Further, the negative correlation between temperature and sunspots is found to persist even when the effect of rainfall on temperature is allowed for. We are forced therefore to imagine that an increase of sunspots somehow causes greater opacity to heat in the atmosphere through some agency not associated with rainfall. On the other hand, the correlation between the American solar radiation measures and temperature is generally positive, but small. The whole discussion finally led to the verdict that the widely prevalent idea of seasonal weather variations being directly controlled by variations in solar radiations is erroneous. As a definite example, there is nothing obvious in solar physics to explain, without reference to previous terrestrial conditions, the contrast between the biggest Indian monsoon on record in 1917 and the monsoon in 1918 which has only been surpassed in scantiness twice in the last sixty years.

The key to the variations of terrestrial weather must therefore be sought within the atmosphere itself in the previous distribution of weather abnormalities. Sir Gilbert's study of world weather from this point of view has been described in two departmental memoirs, both rich in suggestion and so concisely full of facts that they hardly bear condensing into a short description. The quarterly means of pressure and rainfall at some 20 centres over the earth were all correlated one with another, not only for the same season but for one quarter and two quarters

before and after. In all, over three thousand correlation coefficients were worked out and tabulated, so that the papers laid down a thorough foundation for long range weather forecasting in all parts of the world. The generalisation which emerges from the mass of detailed information is that

> " there is a swaying of pressure on a big scale backwards and forwards between the Indian Ocean and the Pacific Ocean, and there are swayings on a much smaller scale between the Azores and Iceland and between the areas of high and low pressure in the North Pacific ; further, there is marked tendency for the ' highs ' of the last two swayings to be accentuated when pressure in the Pacific is raised and that in the Indian Ocean lowered."

Attention has frequently been devoted by European meteorologists to the mechanism of the oscillation in the north Atlantic where an accentuated pressure difference between the Azores and Iceland in autumn and winter is associated with a strong circulation of winds in the Atlantic, a strong Gulf stream, high temperatures in winter and spring in Scandinavia and the east coast of the United States, and with lower temperatures on the east coast of Canada and the west of Greenland. The larger scale oscillation between the Pacific and Indian oceans, briefly named the " southern oscillation ", is shown by the tendency of pressure at stations in the Pacific from Tokio to South America, and of rainfall in India and Java (presumably also in Australia and Abyssinia) to increase, while pressure in the region of the Indian Ocean diminishes.

The mechanism of this oscillation is difficult to understand. It was noticed that the opposing areas in the oscillations were strongly reminiscent of the areas of positive and negative correlation coefficients shown on the chart in the earlier memoir on sunspots and pressure, already referred to. Since the influence of the sun as a direct control has already been ruled out of account, the meaning of this similarity must be that " variations of world-weather tend to occur in a definite manner, *i.e.*, to be associated with definite swayings or surges of pressure, and that changes in solar conditions tend to favour or check these weather changes."

In the search for the cause of these slow swayings of pressure, the most suggestive relationships are those of winter pressure in south America, the changes in which usually precede changes elsewhere ; and the natural inference is that South America is either one of the original controls or is connected directly with it. After an exhaustive examination of the possibility of the relation depending on a sea current, sometimes comparatively warm, at others comparatively cold, leaving south America in winter, Sir Gilbert finally summarises his discussion thus—

> " The natural view is that positive departures in the first group and negative in the second suggest an increase in the general circulation ; but..... this theory is not free from difficulty, and the fuller information now available shows that the explanation of the reversal between the S. Pacific and the Indian Oceans does not lie wholly in the cold currents from the Weddell Sea to the Cape ; for there are controls of South America in the first half-year by previous pressure conditions at San Francisco, the Cape and probably in India, and these controls include reversals just as those exercised by South America. Conditions in the area of the Indian Ocean affect each other closely, but they exercise comparatively little influence on the region of the Pacific Ocean. It may be that the solution of the general problem will not be found until we have a score of years of monthly means of Antarctic and upper air data available.

"There are however grounds for satisfaction in the consistency of the relationships ascertained. If we examine the 150 significant coefficients between the 11 representative centres we shall find that the classification just given directly explains the sign of 149 of them. The solitary exception is the negative effect of Java rain (October to February) upon the Peninsula rain of the succeeding monsoon. This consistency is very remarkable and supports the view that seasonal forecasting is capable of wider application than at present. For the amount that appears capricious in the relationships is materially less than might have been anticipated; so that when the departures from normal of different regions used in forecasting the rainfall of a country point in the same direction and are strongly marked, there is the greater reason for expecting that the conclusion indicated will be realised. To this argument may be added that the rainfalls of Java, India and Rhodesia appear to have far-reaching influence, largely independent of that of the pressures in these areas; and there is every reason for hoping that the tabulation and publication of reliable series of the rainfall of other large areas, in Australia, America and Africa, will have important results".

21. This note on Sir Gilbert's contributions to Indian and world meteorology may conclude with an extract from an appreciation of his work by Captain Brunt, a meteorologist in the British service.—

"Dr. Walker's discussion of the seasonal variations of world-weather form the most comple e discussion of the subject which is available at the present day. In the future it will be possible to supplement this work by the investigation of observations made at other places where observations have not been hitherto available.

"The value of the papers, which represent many years of continuous and strenuous work on the part of Dr. Walker, can scarcely be over-estimated. Quite apart from their direct application to the forecasting of the monsoon rainfall and the light which they throw on the physical causes of variations of weather in India, they establish some very interesting and important relationships between the seasonal changes of weather in different parts of the globe. Whether these changes should be regarded as pure oscillations of the general circulation of the atmosphere in the ordinary sense of the word oscillation, is doubtful. They are possibly oscillations which after a time are damped out and may later be brought back into being with a different phase. And it is on account of this possibility of a change of phase that the method of correlation coefficients adopted by Dr. Walker is superior to the method of harmonic analysis at the present stage of our knowledge. Dr. Walker has shown, as no one else has ever done, how very powerful an instrument for scientific investigation of the earth's atmosphere is afforded by the method of correlation. He has now brought his investigation to a stage at which it is profitable to discuss the results from a purely physical standpoint, as opposed to the statistical method, and the last paper by him to which reference is made above is the beginning of this stage".

22. The foregoing history of the department in Sir Gilbert Walker's time has shown that despite many handicaps, a very material advance has been made during the last 20 years in most branches of our knowledge of Indian and world meteorology.

Indeed it may confidently be claimed that in the face of much that some years ago resembled official discouragement, a very high " yield " has been returned for outlay and opportunities which were totally inadequate considering the importance of the objects in view.

Sir Gilbert retired from service in December last; he was gazetted C.S.I., in 1911 and Kt., in 1924. For him personally the whole department retains the liveliest affection and regard: his kindly sympathy tided over many a period of depression in work, and his enthusiasm, strong sense of reason, and grasp of the true bearings of emerging results were responsible for the noteworthy advances which marked his regime.

23. This short survey brings the department up to the present time, and it is advantageous to summarise the position as it now stands, and to define what is necessary for the future if the department is to make progress in matters ripe for attention.

With existing strength of headquarters staff little more is possible than to keep up mere routine work in a scrambling and unsatisfactory manner. No time is left to officers for such progress as in other countries is regarded as essential in these times. We have to look forward to the certainty that aerial transport is coming east to stay, and India is to reap the immense advantage of being on the direct Empire route to Australia. It is imperative not to be caught unready with upper-air data when that time arrives within the next few years, but the present provision of balloon stations shows poor recognition of this point. In this connection it may be mentioned that in 1918 the balloon station at Lahore was started with the foresight that frontier flying would shortly demand upper-air normals; and fortunate indeed it proved, within a few years, that this had been done. Immediate steps are called for now to set these fresh matters right, and the undertaking is not expensive in comparison with the value of the work to be done. Representations on both staff strength and increase of balloon stations in India are before Government, and it is hoped that the remedies suggested will be found practicable.

Then again there is the difficulty of headquarters location. For 50 years the department has been bundled through a series of temporary quarters in Simla, and is now packed into a building totally unsuited to many of the new activities demanded: the need is to remove headquarters from Simla to the plains, to some place in the direct line of the monsoon where officers can, as they cannot now, get personally busy on research to improve knowledge of upper-air monsoon conditions with a view to accurate forecasting. Proposals on this point are before Government. As regards the actual location Poona suggests itself as suitable, and with the present Agra observatory continuing to speak for the upper-air conditions of northern India, and Poona for the south, it will only be necessary later to adopt a third, but quite subsidiary, experimental station in northeast India for a triangle of major observation to have been obtained, and a great advance to have been secured.

REPORT ON THE ADMINISTRATION OF THE METEOROLOGICAL DEPARTMENT OF THE GOVERNMENT OF INDIA IN 1924-25.

CHIEF FEATURES OF THE YEAR.

The present year completes a half century since the department was constituted on a centralised system, from the originally independent and fragmentary services in provincial areas : and it has seen the retirement of Sir Gilbert Walker, who for some 21 years has very ably directed the policy and work of the department. To mark this stage in the department's history and development, the ordinary annual report has been prefaced by a historical review up to the year 1924.

2. The year under review was marked by considerable activity, made possible by a budget allowing of liberal inspection tours, which have been out of the question on any adequate scale for many years past, and by the relief afforded by the growing acquaintance of our Indian officers with the administration of the department.

3. The measures which were taken in 1922-23 to share in the scheme of severe retrenchment required by the Government of India have not in all cases turned out happily, and it appears now, in the light of experience, that more was attempted than was advisable. So many and vigorous were the protests from public and other bodies in regard to the reduction of reporting stations for the Bengal Daily Weather Report, the stoppage of the Report itself for a part of the year, and the transfer of cyclone-warning duties from Calcutta to Simla, that it was found necessary materially to reduce the measure of retrenchment intended by reverting in some cases to prior practice and expenditure. Perhaps the strongest protests came from the Chamber of Commerce of Bengal, who objected to nearly every step which has affected non-official Bengal ; and in addition to securing acceptance of certain of their minor points, continued to urge Government to reconsider their most insistent demand that the work of cyclone-warning shall be returned from Simla to Calcutta.

4. Such incidents draw attention to the public utility of the department, a utility seldom realised outside the ranks of those who immediately benefit, and only perhaps by them when the benefits are themselves threatened with foreclosure. It is certain that the functions of cyclone and flood-warning alone, though not directly of a revenue producing type, are from time to time the means of saving immense sums to the country, and by themselves constitute a claim to adequate financial treatment, when lines of metcorological advance affecting them are being hampered by lack of funds.

5. During the past year the services of cyclone warning to ports and shipping, and of flood warnings to officers in the irrigation, railway and other departments, were carried out as well as present conditions allow.

The period was marked by heavy localised rainfall causing destructive floods from time to time in various parts of India, but the sea areas were unsually free from severe storms. Warnings for the Arabian Sea were issued during the year on 21 occasions. No storm occurred in this sea area, and the warnings were generally for squally weather due to advances of monsoon, and for western depressions which, in passing through Baluchistan and Rajputana, caused rough weather on the coasts.

For the Bay of Bengal warnings were issued for 35 periods of disturbed weather ; the disturbances developed into storms during 5 of these periods, and into a cyclone during one.

6. An outstanding need for improving accuracy of cyclone-warning is to secure co-operation of ship commanders at sea in the matter of wireless communication of certain standardised sets of meteorological observations. The wide distribution of the printed codes of the department or this purpose has been found ineffective in the absence of such goodwill as can only be secured by suitable resident representation in Calcutta.

With a view, however, to make the best of the present crippled condition of the department, a beginning was made during the year under review with the policy of interesting individual ship commanders by supplying on personal loan reliable instruments for shipboard use, in return for regular weather messages and for special observations when called for by the department. Two good barographs have thus been supplied to the two mail steamers on the Madras-Rangoon run, and the results obtained show that the expenditure has been justified. Any considerable or really effective extension of this policy cannot, unfortunately, be undertaken unless the gazetted staff in Calcutta and Simla is increased.

7. Work continued throughout the year on precise measurements in high-level winds at the Agra headquarters of the upper-air system and the eight outstations of India and Burma ; and an expedition of three observers and equipment worked in Jask, on the southern coastline of Persia, during the monsoon and winter months.

The Agra Upper-air Observatory was started in 1913 on a temporary basis with sanction for 10 years, and as a result of the very solid advantages gained from its investigations, was made permanent, with part of its staff, in 1924.

A branch of its utility lies in association with Army Headquarters to provide for the needs of Artillery and Royal Air Force. This connection becomes closer year by year, and involves, therefore, an increasing amount of incidental work outside the purely meteorological objects of the observatory. Thus as a result of a request by the Royal Air Force reading :—

> " I have recently flown round from Delhi to Peshawar, Quetta and Delhi and have used 3 of your forecasts.
>
> All 3 were remarkably correct in every detail. Please allow me to congratulate you on these results.
>
> I want the Royal Air Force to use your forecasts much more freely both for travelling flights and for operational work. Can you let me know whether you can supply these as required ?"

such forecasts on demand were promised by the Simla Meteorological office, to be based partly on regular or extra observations at upper air stations.

The character of the co-operation of Agra with the Artillery has been mentioned in previous annual reports, and with regard to the Royal Air Force, consideration was given by Government to questions of relative incidence of work and expenditure between the Royal Air Force and the meteorological department in a scheme for satisfactory co-operation on the frontier.

8. Assistance from our Simla and Agra offices and their upper-air outstations was asked for, given, and gratefully acknowledged on the occasion of the U. S. A. flight and Squadron Leader Maclaren's flight through India. The acknowledgments indeed, were couched in terms which increased even the Department's own realisation of the essential necessity of current upper-air information in any flying service in the East.

9. In general it may be said that such physical experimental work as Agra undertakes on upper-air conditions is now regarded the world over as the next essential to meteorological advance. In India especially is it necessary ; and, given

proper facilities, it is likely to form in future the most active part of the programme of this department. On this account there has for some time past been a realisation that a really live headquarters of this department must in future be stationed in the plains, at some place where typical conditions of Indian weather prevail, and that a move from Simla was called for. Northern India, with its hazardous contact with the monsoon, is well represented in this matter by Agra, and a proposal to move headquarters from Simla to Poona, in the direct path of the more vigorous monsoon fresh from the Arabian Sea, and there to provide adequate means for this newer type of work, was put before Government.

10. In matters of research and publication we had the work of Sir Gilbert Walker, now issued in the departmental Memoirs,

Correlation in seasonal variations of weather, IX—A further study of world weather.

Correlation in seasonal variations of weather, X—Applications to seasonal forecasting in India.

Monthly and annual normals of rainfall and of rainy days, (from records up to 1920), and

Frequency of heavy rain in India.

In the press, also, was an atlas by Dr. Normand, of storm tracks in the Bay of Bengal, brought up to 1923 inclusive.

LEAVE AND APPOINTMENTS.

11. Sir Gilbert Walker went on 6 months' leave preparatory to retirement, from 14th June 1924, Dr. C. W. B. Normand officiating as Director-General up to the 9th October and Mr. J. H. Field, on return from leave, up to the 13th December 1924.

Mr. J. H. Field returned from leave on the 10th October 1924 and was later appointed Director-General of Observatories in succession to Sir Gilbert Walker, from the 14th December 1924.

Mr. V. V. Sohoni went on one month's leave on the 20th March 1925.

Mr. V. Doraiswamy Iyer was appointed Assistant Meteorologist from the 14th April 1924, and was granted leave for 3 months and 12 days from the 27th February 1925. Mr. Mukand V. Unakar acted as Assistant Meteorologist during his absence.

Mr. M. G. Subrahmanyam returned to duty after 3 months' leave on 12th April 1924. Mr. Hans Raj Puri acted for him during his absence.

Mr. Barkat Ali was appointed Assistant Meteorologist on probation from the 16th April 1924.

Dr. T. Royds went on combined leave for 13 months from the 24th November 1924, and during his absence Mr. A. A. Narayana Ayyar, Assistant, was placed in charge of the duties of Director, Kodaikanal Observatory.

Mr. S. Sitaramayya who had been granted combined leave for 28 months from 9th September 1922 was allowed to return from leave; he joined duty at Agra on the 16th April 1924.

THE SYSTEM OF STORM WARNING FOR PORTS AND SHIPPING.

12. The work of warning ports and shipping in the Arabian Sea and the Bay of Bengal of the approach of cyclonic storms or of bad weather was done throughout the year from Simla. Thirty-one ports are on the warning list for storms in the Arabian Sea, and thirty-nine ports, fourteen River Police Stations and 40 District

Police stations for storms in the Bay; of the Bay ports, twelve get additional information regarding the particular areas in which weather is disturbed, a special system of 'locality signals' being in use for this purpose. Shipping at sea is also supplied with the latest weather information by means of wireless bulletins, which are broadcasted twice daily, or more frequently if the occasion demands it, rom the radio stations at Bombay, Karachi, Calcutta, Rangoon, Madras, Matara (Ceylon) and Aden. The weather bulletins from Matara and Aden were started in March 1920 at the request of the Admiralty. A complete account of the warning system may be found in the "Code of Storm Warning Signals for use at Indian Ports," obtainable at Calcutta from the Superintendent of Government Printing, India.

Warnings to Ports and Shipping in the Bay of Bengal.

13. During the year warnings were issued for thirty-five periods of disturbed weather; the disturbances developed into moderate storms during five of these periods, and into a severe storm once. The last mentioned storm was generated to the southwest of the Andamans on the 15th November, moved at first westnorthwest and later almost north to cross the Madras coast near Gopalpur on the morning of the 19th. It thus threatened a long stretch of coast line before actually passing inland. The warnings issued for this storm, as well as for most of the other periods of disturbed weather, were satisfactory.

14. As an instance of the usefulness of the warnings it may be mentioned that in the cyclone of November last, the S. S. "Beme", lying in Cocanada, telegraphed to Simla to know whether she should proceed, and decided on receipt of reply to lie up for 36 hours, and then steam south in her passage to Rangoon to dodge the cyclone position. In the same cyclone, three of the Asiatic S. N. Co.'s steamers marked time at the head of the Bay until the Simla broadcasts showed that it was safe to move on.

15. Two important criticisms, however, were received. One from the Deputy Port Conservator at Calcutta, dated the 4th August 1924, made the following 7 statements :—

(1) "Yesterday it was obvious to everyone that weather was very unsettled at the head of the Bay but no warning of any description was received either from Simla or locally".

(2) "At 2-20 P. M. a telegram was received from Simla reading as follows—"Deep depression with centre near Sandheads moving west-north-west winds comparatively weak at present neighbourhood centre, but unusually strong remainder of Bay hoist *distant* cautionary signal No. 1".

(3) "3 P.M. telephoned to the local Meteorological Office; was informed by head clerk that Meteorologist was not in office. Was told that the storm centre was 50 miles southeast from Saugor Island. Head Clerk stated that his office could take no further action without instructions from Simla".

(4) "4 P.M. Telephoned to Meteorological Office again. Was informed by head clerk that Meteorologist had gone to the Presidency College, and was not expected back before the evening. He communicated telegram received from s. s. *Nam Sang*, at 13 hours, reading as follows—"Position 91'-30" E. 16'-30" N. wind southwesterly gale force, sea very rough, weather becoming worse". On being questioned head clerk stated that his office was taking no steps as regards further local observations.

(5) "Under the circumstances Signal No. I is valueless both to ocean going vessels, and to local craft. Should the storm develop in intensity, and should it be necessary for us to place small craft in shelter, approximately 12 hours must elapse before this can be carried out completely".

(6) "I take a very strong view of the manner in which warnings are being issued, and feel that the matter should be strongly represented to Government".

(7) "On our own responsibility we have hoisted No. 4 Storm Signal".

16. This letter was discussed at a meeting of a committee of the Bengal Chamber of Commerce with the officiating Director-General, who pointed out that the second part of (1) was incorrect, inasmuch as special telegrams about weather at the head of

the Bay had been sent both at noon and at 9 P. M. on the 3rd August to Calcutta port officials, who had received these messages. With regard to (2), (5), (6), (7) it was explained that the telegram sent at noon on the 4th purposely used the term "depression" and not "storm", because ships and ports near or to the north of the centre of the depression were not considered to be in danger; consequently the "cautionary" and not the "storm" signal was ordered to be hoisted; and, it may be noted, the next day's observations showed that the depression had moved west-north-west, exactly as forecasted, without causing stormy weather at the Hooghly ports. With regard to (4) and (5), the Calcutta Daily Weather Report's mention of a small storm near Saugor Island was unfortunate, while the Head Clerk's reply to the Deputy Port Conservator over the telephone was quite misleading, inasmuch as Simla was getting special observations from Calcutta every 8 hours and the Superintendent at Calcutta was examining frequently the records of the self-recording instruments and would have sent Simla a priority telegram in the event of any unexpected change. Thus the Simla warnings to Calcutta, though not trusted, were in fact good, but the telephonic information given by the Calcutta Head Clerk was misleading.

17. From the Deputy Port Conservatory at Rangoon a criticism was received regarding the warnings issued on 1st September 1924. His letter read as follows—

> "On the 1st September 1924, a storm of moderate intensity struck the Port at about 3-30 P.M. The weather telegram intimating the formation of a depression with squally weather between the Andamans and Diamond Island that might develop into a storm, together with cautionary weather signals to be hoisted for the information of shipping, was only despatched from Simla at 12-35 P.M. on the 1st September and reached this office at 3 P.M. on the same afternoon. This gave very little time to warn local shipping of the approaching bad weather and, while no report of damage to sea-going vessels that arrived in the Port after the 1st September 1924 was received in this office, damage to river craft was fairly general. I presume that in this instance the depression formed so quickly in the Bay that it was not possible to acquaint this office any earlier than was done of the approaching bad weather".

The weather situation in the Andaman Sea became slightly suspicious on the morning of the 31st August, and special observations were called for from the coast stations that evening. Neither the morning nor the evening observations seemed, however, to justifiy the hoisting of any signals at Rangoon. By the next morning a depression had formed with centre some 60 miles east of Preparis Island, and later developed into a storm, which moved west-north-west during the next three days, but its centre was at no time within two hundred miles of Rangoon. In view of this distance of the depression centre the force of the squalls at Rangoon on the afternoon of the 1st was unexpectedly great; and the failure to hoist the local cautionary signal at an earlier hour was not due to neglect but to the definite belief that it was not justifiable.

Warnings to Ports and shipping in the Arabian Sea.

18. The west coast ports are warned not only for storms but also for squally weather, especially at the beginning of the monsoon. There were 21 periods of disturbed weather for which warnings were issued: during 16 of these the warnings were for squally weather or strong winds connected with the monsoon, and during the remaining 5 for rough weather off the Mekran coast due to the passage of western depressions through Baluchistan. There was no cyclonic storm in the Arabian sea during the year.

FLOOD AND STORM WARNING, AND WEATHER FORECASTS TO DISTRICT IRRIGATION, RAILWAY AND OTHER OFFICERS.

19. This work was done wholly by the Simla Meteorological Office. The arrangements have been made at various times and differ considerably in character, according to the nature and extent of the flood or weather warnings required by those concerned. In most cases the officers require telegrams either warning them of

advancing storms likely to give heavy rain or informing them of the actual occurrence of heavy rainfall likely to cause severe floods which might injure railways or canal works; and in other cases, they require warnings or forecasts of the weather for as long a period beforehand as possible.

20. At the end of the year the listed number of district officers and officers in the irrigation, railway and other departments to whom flood warnings, weather forecasts or intimations of the likelihood of rain during the dry season were to be sent by this department was 205. There were also 19 officers of the Telegraph Department requiring warnings, mostly for strong winds.

In order to provide against serious loss of life and property in inland Bengal when a cyclone from the Bay crosses the coast, 461 officers were added in 1921 to the warning list; of these officers 40 hoist the signals shown in Appendix D of the "Code of Storm Warning Signals" whenever instructed to do so.

21. The number of special forecasts and warning messages issued by the Department during the year was 1616, and in addition 702 telegrams of actual heavy rainfall were sent by meteorological observers direct to various officers.

Reports were received from 54 of the officers on the warning lists. Of these 40 stated that the warnings were satisfactory, 7 gave no remarks, and the remaining 7 offered suggestions or minor criticism, which have received consideration.

On the whole a comparison of the warnings with the actual subsequent rainfall, or the tracks of storms inland, show that the system is working satisfactorily and that most of the warnings issued were of value to the recipients.

Warnings to Military Authorities.

22. Telegraphic forecasts of the likelihood of bad weather were sent throughout the year to Headquarters, Waziristan and the Officer Commanding, Royal Air Force, Dardoni, and were stated "to be timely, accurate and most useful". Special warnings were issued to the General Officer Commanding, United Provinces District, Meerut, as well as to the General Staff Branch of the Army Headquarters, in connection with the Eastern Command Manoeuvres which took place between the 15th and the 21st January 1925; the General Staff Branch reported that the forecasts had been very helpful to all concerned. Warnings were also issued to the Officer Commanding, 4th Infantry Brigade, Nowshera, in connection with Brigade training during the later part of January; the Officer Commanding, in asking for earliest news of approaching rains during the 10 days beginning on the 22nd January expressed gratitude for the accuracy of the forecasts made to him previous to that date.

Warnings to Aviators.

23. From time to time telegraphic weather warnings were supplied to various aviators, and it is satisfactory to note that almost invariably the forecasts were reported to have been correct and useful. The American aviators who flew round the world were supplied with such information, in a series of some 200 telegrams from meteorological stations between the Persian Gulf and south Burma, as well as from Simla headquarters.

24. The following appreciations of the department's warnings are of interest:—

The Aeronautical Engineer, Air station, Monkey Point, Rangoon says:—

"There is no doubt whatever your telegraphic weather reports both from local stations between Calcutta and Rangoon, and also Rangoon and

Tavoy, as well as your more general report from Simla, sent at the time the world flights were passing over this part, were of the utmost utility.

The United States flight and Major Maclaren both passed over the Rangoon-Akyab section on the same day. On the following day the United States flight continued to Calcutta and one day later Major Maclaren left for Bangkok but made a halt at Tavoy.

All these flights were started on these particular days, owing to the improved weather conditions along the routes as shown by your reports. .... Upper air reports were of course the most useful ".

The American Consul, Calcutta, wrote as follows :—

" On behalf of the American Aviators and Naval Officers recently in Calcutta I desire to extend to you my hearty and cordial thanks for the very valuable assistance which you and the members of your staff rendered to them in promptly and regularly transmitting reports on weather conditions.

Flight Commander Lieutenant Smith asked me particularly to tell you of his appreciation of your unusually fine co-operation and of the high quality of the reports submitted. They have contributed largely to the success of the flight throughout India."

25. Royal Air Force, Headquarters, in a note on operations in Waziristan intimated that :—

" The air staff would like to express to you their gratitude for the trouble you have taken in this matter.

The reports have been of the greatest value, and I have heard from the pilots how much they have appreciated them ".

26. The Chief Staff Officer of Royal Air Force, Headquarters wrote on the 21st February 1925, that : —

" I have recently flown round from Delhi to Peshawar Quetta and Delhi and have used 3 of your forecasts.

The first said that the weather at Peshawar would break on Tuesday 10th ; the second that there would be fine weather over the Zhob on Thursday 12th and Friday 13th ; the third that the weather would be fine with poor visibility on Wednesday 18th and Thursday 19th in Rajputana. All 3 were remarkably correct—in every detail. Please allow me to congratulate you on these results.

I want the Royal Air Force, to use your forecasts much more freely both for travelling flights and for operational work ".

27. In the near future there is the probability of closer co-operation of the department with the Royal Air Force as the development of civil and military aviation progresses ; and plans about appointment of forecasting meteorologists at centres like Quetta, Peshawar and Karachi were discussed during the year.

Supply of Meteorological Information.

28. From time to time special information is supplied to the meteorological departments of England, Australia and Egypt. Climatological and other data, at times involving special calculations are also provided for sanitary and other

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officers of Government as well as for those private firms who are willing to pay for the service. The extent to which the department was utilized in this manner during the last year will be seen from the curves B and C in the graph at the end of this report.

Upper Air Work.

29. Exploration of the free atmosphere in India has been recognised as indispensable in the interests of aviation, general meteorology, and both daily and seasonal forecasting. This recognition found its expression in Government's order of April 1924, placing the Agra observatory on a permanent footing and establishing the nucleus of a permanent staff there. The principal routine work of the year at that observatory consisted as before of

(*a*) supplying material and equipment to the upper air stations at Quetta, Peshawar, Lahore, Simla, Diamond Harbour, Akyab, Bangalore and Bombay.

(*b*) exercising close supervision over work at outstations.

(*c*) tabulation of pilot balloon results and of cloud observations.

(*d*) flights of instrument balloons—69 were sent up, and 41 recovered.

(*e*) repair to barometers and anemometers.

(*f*) construction of Stevenson screens—65 were made and sent to various observatories.

The new engine house, begun in November 1923, was completed in February 1925 and the erection of plant was taken in hand.

30. An interesting activity of the year, was an expedition of 3 observers to Jask on the Persian Gulf for a year's series of pilot balloon observations, beginning on 4th June 1924. The expedition was undertaken to collect upper-air data in an unsurveyed part of the Imperial air route, and also to throw some light on the physical causes of breaks in the monsoon.

31. The Agra observatory as usual supplied equipment for pilot balloon work at 8 artillery practice camps during the winter.

At the request of Royal Air Force, a batch of 6 Royal Air Force wireless operators was trained in Agra in pilot ballon observation, in August 1924; some of these keep in touch with the work, by helping the department's observers at Quetta and Peshawar.

His Excellency the Governor of the United Provinces visited the Agra observatory on the 15th August 1924.

Observatories.

32. *Bombay.*—The routine activities of the observatory and the Meteorological Office consist of registering continuous records of magnetical, meteorological and seismographic instruments, taking numerous eye observations, reduction and tabulation of these data, publication of a Daily Weather Report (for 6 months—May to October—under present arrangements), taking star or sun observations for time determination, rating a large number of chronometers belonging to the Royal Indian Marine and the Royal Navy, directing the local time-ball service for the harbour and collecting extracts from weather logs of ships. All these were satisfactorily carried out during the year; about 60 chronometers were rated and issued, and 950 weather logs from ships were collected. Some headway was made in preparing hourly normals of meteorological elements based on data for 1846-1920.

The Alibag Magnetic Observatory, where the leaky condition of the roof was causing great anxiety last year, was fully overhauled at a cost of over Rs. 7,000 before the monsoon rains of 1924 began.

33. *Calcutta, Alipore.*—In addition to the issue of the Daily Weather Report for northeast India, the Calcutta office and observatory have the important duties of supplying all the Indian observatories with instruments and stores, keeping a stock of tested instruments, checking and computing a portion of the data accumulated from observatories, supplying mean local time to the Port of Calcutta and by wireless to shipping at sea; distributing the departmental publications and attending to some of the routine correspondence of the department as a whole.

34. The insistent protests from the commercial public of Calcutta led to the restoration of the Daily Weather Report to its pre-retrenchment form from the 7th April 1924, with resumption of continuous publication throughout the year. A new system of issuing early weather information by telephone was introduced from 19th July 1924 for subscribers to this local service. In connection with the warning service, for storms at sea it had been found necessary for Simla, when the work is done, to keep Calcutta observatory informed on all special observations received, by sending coded messages to communicate their substance. This arrangement, however, was not found fully satisfactory, and it was subsequently decided that the Calcutta office should receive duplicate telegrams of all special observations direct from the observatories, and be thus enabled to supply the public fairly rapidly with the latest information about storms or disturbed weather.

35. The determination of time from transit circle observations of stars improved considerably during the year. In April the times of transmission of the wireless time-signals were changed from 7 A.M. and 7 P.M. (I. S. T.) to 2 P.M. and 10 P.M. (I. S. T.); the electric diffuser was generally used for this transmission.

36. The Meteorologist, as a member of the North Bengal Flood Enquiry Committee, undertook the preparation of statistics on rainfall from data of the period 1870 to 1921, obtained from various sources. A fairly exhaustive piece of work on excessive rainfall and its relation to floods was carried through and a report submitted to the Government of Bengal in January 1925.

37. *Madras.*—The most important routine work, the supply of time to the local shipping and the whole country generally was carried on well. The issue of the Daily Weather Report was limited as in the previous year, to the 9 months from April to December.

38. *Kodaikanal.*—The Director of the Solar Physics Observatory published a report on the astronomical work of 1924. The collection of spectroheliograms from other observatories, for days on which complete observations at Kodaikanal were impossible, continued as a part of the programme of the International Astronomical Union.

39. *Agra.*—The Aerological Observatory continued its most important and fruitful activities. A full report may be found on page 28.

40. *Other Observatories.*—A number of observatories keep continuous instrumental records of certain meteorogical elements; 6 stations record wind by Beckley anemographs, 4 by Dines' anemograph, 6 record hours of sunshine, 15 deal with air pressure, 7 with air temperature, 9 with terrestrial radiation, 2 with underground temperatures, and 1 with solar radiation.

41. Of the purely meteorological observatories under the department's care 47 were non-departmental and 214 were maintained by the Government of India; these include stations as far afield as Tehran, Kashgar, Aden and Seychelles. According to the classification given in the report for 1918-19, the departmental observatories consisted this year of 5 of the first claass, 180 of the third class, 6 of the fourth class and 23 of the fifth class. The maintenance of these observatories the supply to them of tested instruments, and the careful scrutiny of their observations naturally entail much work of a routine character at headquarters. The

correctness of observations depends upon the continuance of good exposure and good condition of instruments at observatories, and upon the accuracy of reading by observers. The former point can only be ensured by visits of inspection by trained officers. The latter point can to some extent be estimated at headquarters from the number of mistakes detected in the data for the Indian Daily Weather Report. The stations of great reliability in which no mistake or at most one has been detected, numbered 32 and the number at which more than 50 mistakes were made was 5. The average number of mistakes during the year at the remaining stations was 10.

Inspection of Observatories.

42, One of the essentials for continued accuracy of meteorological observations is frequent inspection of observatories. This feature had been neglected for many years owing either to want of funds or to inadequate staff: but a marked improvement had taken place during 1923-24 with the inspection of about 90 observatories, chiefly those on the coast lines between Rangoon and Karachi. During 1924-25 the previous year's record was maintained, thanks to sufficient travelling grants, and 80 observatories from the western frontier to Burma, and 8 in south India, were inspected by Meteorologists and others. The Director-General visited the principal observatories at Bombay, Agra and Alipore (Calcutta).

MARINE METEOROLOGY.

43. Wireless weather messages from ships at sea, and extracts from weather logs of ships calling at the principal ports on the Indian seaboard, are the chief sources of marine data collected by the department.

44. The object of the system of radio-messages from ships is mainly to supplement the coast observations in cyclone-warning work. In the absence of observations from sea areas it is not always easy to draw correct conclusions about the position, movement and intensity of storms; this is the case particularly with disturbances in the Arabian Sea for which inferences had in the past to be drawn from very insufficient observations from the west coast line of India. The system of wireless weather messages which was started in 1914, but which was necessarily suspended during the war, was resumed in 1921. It showed improvement over preceding years during the year under report; thus the number of ships' messages from the Bay and the Arabian Sea totalled 3,633, in comparison with 2,237 in the previous year and 956 in 1921-22. The department gratefully acknowledges the assistance given by commanders of ships who took part in this service, and would especially mention the following steamers from whom more than 40 weather messages were received during the year.

S.S. *Angora* ..	104	S.S. *Ethiopia* ..	48	S.S. *Nawab* ..	65
„ *Arankola* ..	59	„ *Ellora* ..	53	„ *Nurjehan* ..	52
„ *Begum* ..	61	„ *Egra* ..	105	„ *Ormara* ..	58
„ *Badarpur* ..	77	„ *Goalpara* ..	50	„ *Orna* ..	59
„ *City of London*	55	„ *Havildar* ..	45	„ *Pasha* ..	44
R.I.M.S. *Clive* ..	103	„ *Manipur* ..	63	„ *Shahjehan* ..	64
S.S. *Chindwara* ..	44	„ *Maharaja* ..	175	„ *Shahzada* ..	86
„ *Chyebassa* ..	53	„ *Namsang* ..	43	„ *Varsova* ..	42
				„ *Warialda* ..	46

This is a gratifying increase, but even yet the department's warning officers frequently lack, at critical times, ships' observations from the vicinity of a storm at sea and find themselves compelled to draw their inferences and base their broadcast messages on coast observations alone. It is hoped that as more ships come to

co-operate with the warning service the number of such occasions will steadily diminish. It would be most helpful if co operating captains would induce others to take a share in this service of information from sea.

45 The Madras-Rangoon mail boats were provided with two good barographs, in accordance with the policy of issuing instruments on loan to ships' commanders. The results have been satisfactory and this policy if extended, would certainly be fruitful in increasing a knowledge of the meteorology of the Indian Seas ; but lack of sufficient gazetted staff does not at present allow of an extension in this direction.

46. Apart from ships' wireless messages, an important source of data is the log extracts taken by clerks in Calcutta and Bombay. In this connection a new opening was created in Rangoon, where, through the helpfulness of the Port authorities, the observers of the Time-Ball and Tidal observatory of the Port Commissioners are entrusted with the collection of ships' data. Occasionally, in special cases, logs of steamers with experience of disturbed weather are collected at Madras ; and the Colombo Port authorities also help us similarly whenever requested. A total of over 2,000 logs was recorded at the end of the year.

The data thus obtained are entered on charts of disturbances in the Bay of Bengal and the Arabian Sea, and kept for reference in the storm-warning work of the department, and in drawing up an account of the storms of the year for publication in the India Weather Review (Annual Summary).

An atlas of Storm Tracks in the Bay of Bengal during the period 1891 to 1923 was prepared, and was on the point of publication at the end of the year.

Rainfall Registration.

47. The registration of rainfall in India has always been carried out under the control of provincial authorities. In 1889 a uniform system was introduced by the Government of India, and the Director-General of Observatories was made consulting officer in connection with this work. His advice is sought regarding the starting of new rain-gauge stations, and he receives annual reports upon the efficiency of the work from the local controlling officers, who are in most of the provinces the Directors of Agriculture or of Land Records.

48. The following is a statement of the number of raingauge stations, totalling nearly 3,000, which supply data for publication in the " Rainfall of India " as they stood in January 1925 :—

Province.	Number of stations.	Province.	Number of stations.
Burma	240	Baluchistan	79
Assam	125	Sind	14
Bengal	251	Rajputana	145
Bihar and Orissa	316	Bombay	274
United Provinces	275	Central India	85
Punjab	191	Central Provinces	188
Kashmir	41	Hyderabad	18
North-West Frontier Province ..	33	Mysore (excluding raingauges in taluks).	77
		Madras (including Feudatory states)	524

49. In 1920 the necessity of frequent inspections of raingauges was brought to the notice of the officers in charge of rainfall registration, and subsequent reports have shown a decided improvement in this respect.

The following notes are based on the reports for 1924-25 of these officers :—

Burma.—There were 241 stations as against 239 last year; 18 were meteorological observatories, 30 under the Public Works Department, 2 belonging to the Agricultural Department and the rest under the supervision of civil officers. 217 raingauges were inspected as against 198 in the previous year, out of which almost all were reported to be in good condition; the main defects were, as usual, nearness to buildings and trees.

Assam.—There were 125 stations at the end of the year. The number of raingauges inspected was 114, against 105 in the preceding year. The districts are generally well equipped with raingauges and their accessories.

Bengal.—The number of raingauges at the end of the year was 251. The number of stations inspected was 197 as against 202 in the preceding year. The condition of the raingauges in the province is reported to be good on the whole, defects pointed out by inspecting officers being remedied very promptly.

Bihar and Orissa.—There were 316 raingauges (including 30 in the Feudatory and Tributary Mahals of Orissa) out of which 255 were inspected.

United Provinces.—There were 286 rain-reporting stations, including the meteorological observatories, as against 288 last year. Out of 270 stations under District and Canal Officers 78 per cent. were inspected during the year as compared with 75 per cent. in the previous year.

The Punjab.—There were 191 raingauge stations at the end of the year 1924 as against 189 in the previous year. Of these 130 gauges were inspected during the year 1924.

North-West Frontier Province.—There were 34 raingauges: out of these 30 were inspected and reported to be in good working order, except that at Kohat with regard to which necessary action was being taken.

Baluchistan.—There were 79 raingauges as in the previous year in addition to 9 meteorological observatories. Eighteen raingauges in charge of Civil Department were inspected by District Officers, while the railway raingauges were frequently inspected by the officers of the railway department.

Bombay.—There were 277 stations in the Presidency proper of which 242 were inspected as against 237 in the previous year; while out of the 61 raingauges in the Indian States 40 were inspected. In the previous year there were 54 inspections of raingauges in the States; the decrease is due to the transference of the gauges in Cutch and Kathiawar to the control of the Government of India. The maintenance of the rainfall registration system was quite satisfactory.

Rajputana.—Reports on the rainfall registration were received from all the States. In all there were 326 raingauge stations, out of which 290 were inspected as against 308 last year.

Central India.—Reports on the rainfall registration were received from almost all the States in the Central India Agency with the exception of Indore.

There were 148 raingauges in all the States and Agencies, out of which 142 stations were inspected as against 139 last year. The condition reported was on the whole good.

Jammu and Kashmir State.—There were 41 stations altogether, out of which 8 are meteorological observatories. The number of raingauge stations inspected during the year was 21 against 15 last year. " Every endeavour is being made to have all the raingauges inspected at least once a year."

Central Provinces.—The number of raingauges in the Central Provinces was 125 and those in Berar 43, the number of inspections in the former being 309 and in the latter 115 against 292 and 97 respectively in the previous year.

Hyderabad.—No report has been received.

Mysore.—The number of raingauge stations remained unchanged, *i.e.*, 226. Of these 77 are at district and taluk headquarters and the rest in villages. 203 stations were inspected in 1924-25 as compared with 196 in the previous year; no less than 117 stations were inspected more than once.

Coorg.—7 out of the 10 raingauges were inspected and found to be in good order.

Madras.—There were 492 raingauge stations in the Madras Presidency and feudatory states on 31st March 1925. The number of stations inspected during the year was 470. The condition of the raingauges was generally good.

A general review of the report shows the satisfactory fact that in practically all the divisions over 75 per cent. of the raingauges were inspected, while in some the percentage was as high as 90.

50. *Heavy Rainfall Reports.*—Heavy rainfall is occasionally so very local that small areas can have as much as 10″ of rain without the Daily Weather Report conveying the least suggestion of it. With a view to have such useful data promptly available for the Daily Weather Report it was arranged in 1921, with the approval of the Government of India, that reports of 5 inches or more of rainfall should be

telegraphed to Simla from raingauge stations at district headquarters throughout the country. The number of such telegrams was 180 during 1924-25 as compared with 218 in the previous year.

Snowfall Registration in the Mountain Districts to the North and West of India.

51. Information as to the amount, distribution and time of occurrence of the snowfall in the Himalayan and Afghan mountain areas was on the whole tolerably complete, and the thanks of the department are due to the various officers who collected and forwarded it.

Seismological Observations.

52. Seismological observations were recorded throughout the year by two Omori-Ewing seismographs at Simla, two at Calcutta and one at Bombay, and a Milne seismograph at Kodaikanal. At Bombay (Colaba) the new Milne-Shaw machine has worked excellently since its installation in 1922-23 and the Meteorologist there has undertaken a study of the microseisms that appear just before the setting in of the monsoon. All the seismic data collected at these places are sent to the Seismological Committee of the British Association.

Time Signals.

53. The observatories at Madras, Calcutta and Bombay determine time from star and sun observations and communicate it to the local ports by time-ball signals. The distribution of time over the country generally is made from the Madras Observatory by a signal transmitted daily at 16 hours I. S. T. over the Indian telegraph system; considerable errors are inevitably introduced into the signal at stations where retransmission is effected by hand. A wireless time signal for the use of ships was broadcasted automatically twice daily from the Alipore Observatory at 2 P.M. and 10 P.M. I. S. T. through the Calcutta radio station.

A wireless receiver was put up at the Bombay Observatory and was used regularly from November 1924 for a comparison of the local time determination with the time signals transmitted from Calcutta, Eiffel Tower and Nauen.

The time work was satisfactory throughout the year.

Publications and Library.

54. The routine publications of the departments are mentioned in the Administration Report for 1922-23. The Calcutta Daily Weather Report was restored to its original form from the 7th April 1924.

The Daily Weather Telegram was despatched to subscribers daily about noon, and the weekly rainfall summary was supplied to the *Gazette of India*. The Weekly Weather Report, containing matter similar to the Weekly Summary published in the *Gazette of India*, was published during the monsoon period, and supplied to about 75 subscribers and also to the Press.

The quinquennial volume for 1916-20 of the Bombay Observatory was sent to press and was about to issue at the end of the year. The Annual Volume for 1921 was also sent to press, while the manuscripts for the Annual Volume for 1922 were almost ready for printing.

Orders were received about the abolition of the free exchange of publications between the department and officials of provincial Governments from the next official year and appreciable reduction of the distribution lists was accordingly anticipated. The number of institutions etc., on the distribution lists of the department was 410 at the end of the year.

The following memoirs of the Indian Meteorological Department were published during the year :—

Volume XXIII, Part VIII, "Frequency of heavy rain in India," by Sir Gilbert T. Walker.

Volume XXIV, Part IX. "Correlation in seasonal variations of weather, IX, A further study of world-weather", by Sir Gilbert T. Walker.

Volume XXIV, Part X, "Correlation in seasonal variations of weather, X, Applications to seasonal forecasting in India", by Sir Gilbert T. Walker.

55. Books, periodicals and pamphlets, either purchased or received as presentation copies in the department's libraries at Simla and Calcutta during the year numbered 779. In the library at headquarters the longstanding arrears in classification were cleared up, and in addition 178 current books and pamphlets and 582 periodicals and publications containing data were catalogued and indexed.

Concluding Remarks.

56. The Meteorological Department owes a large part of its usefulness to the sympathetic assistance it receives from other departments. Civil Surgeons and other officers of Government departments, as honorary superintendents of observatories and in other capacities, help in the meteorological work ; the Posts and Telegraphs Department assists in the rapid transmission of meteorological information ; at the same time they allow their employees to act as observers. The Indo-European Telegraph Department, also, by giving free transit to the daily messages from the Persian observatories, places a large amount of most useful information at the disposal of the Meteorological Department. Weekly telegrams are received from April to September from the Director, Royal Alfred Observatory, Mauritius, and from April to October from the departmental observatories at Zanzibar and Seychelles. These telegrams give valuable information of the weather conditions in the Indian Ocean, and the department is indebted to the officers indicated for the punctual transmission of the information. Thanks are due to the Director of the Royal Alfred Observatory also for his courtesy in placing the meteorological data of that observatory at our disposal.

The department is greatly indebted for important information on meteorological conditions prevailing before and during the south-west monsoon to the Controller, Physical Department, Cairo ; the Directors of the Observatories at Buenos Ayres Santiago and Batavia ; the Astronomer Royal, Cape Town ; Director, L'Observatoire Physique Central, Leningrad ; the Secretary, Friends' Industrial Mission, Banani Pemba, Zanzibar ; the Principal Medical Officer, Tanganyika Territory, Dar-es-Salaam ; the Commonwealth Meteorologist, Melbourne ; Director of Agriculture, Salisbury, Rhodesia ; Chief of the Weather Bureau, Washington ; and to the various officers around the Indian frontiers who have collected and supplied valuable snowfall information.

The thanks of the Department are due to Mr. A. J. Bamford, Superintendent of Colombo Observatory, for the very useful help he has rendered from time to time in connection with storm warning work. The department is also grateful to the Director, Koninklijk Magnetisch en Meteorologisch Observatorium, Batavia, Java, who has arranged for taking and telegraphing to Simla daily observations from Sabang in Sumatra during the cyclone months April, May and October to December.

Simla ; J. H. FIELD,

The 12th August 1925. *Director-General of Observatories.*

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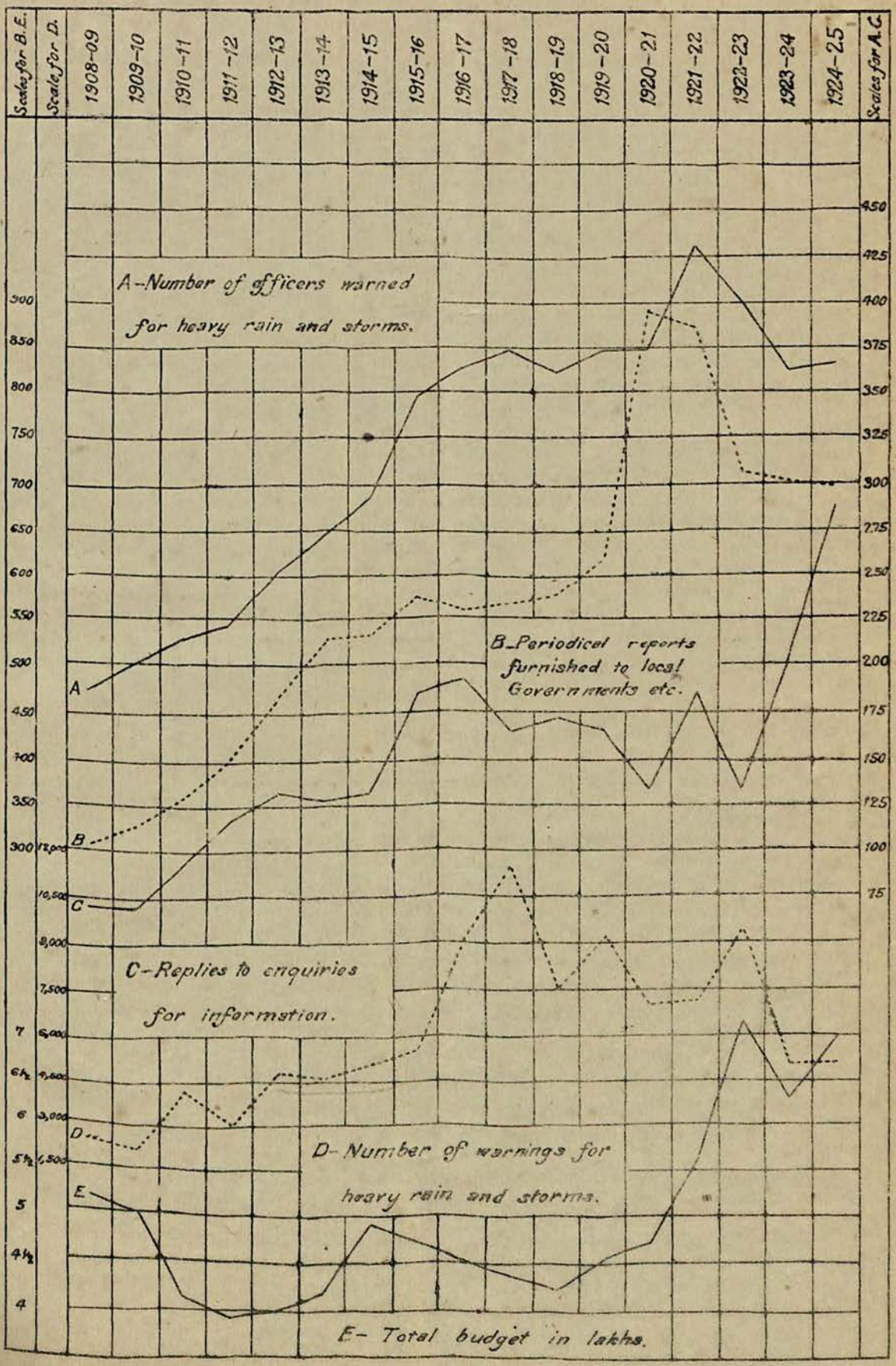
GROWTH IN ACTIVITY AND COST



LIBRARY
OF THE
BOMBAY
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OF THE

Report on the Administration of the Meteorological Department of the Government of India in 1925-26, and a Note on the Long-Established Observatories of Madras and Bombay.

OF THE
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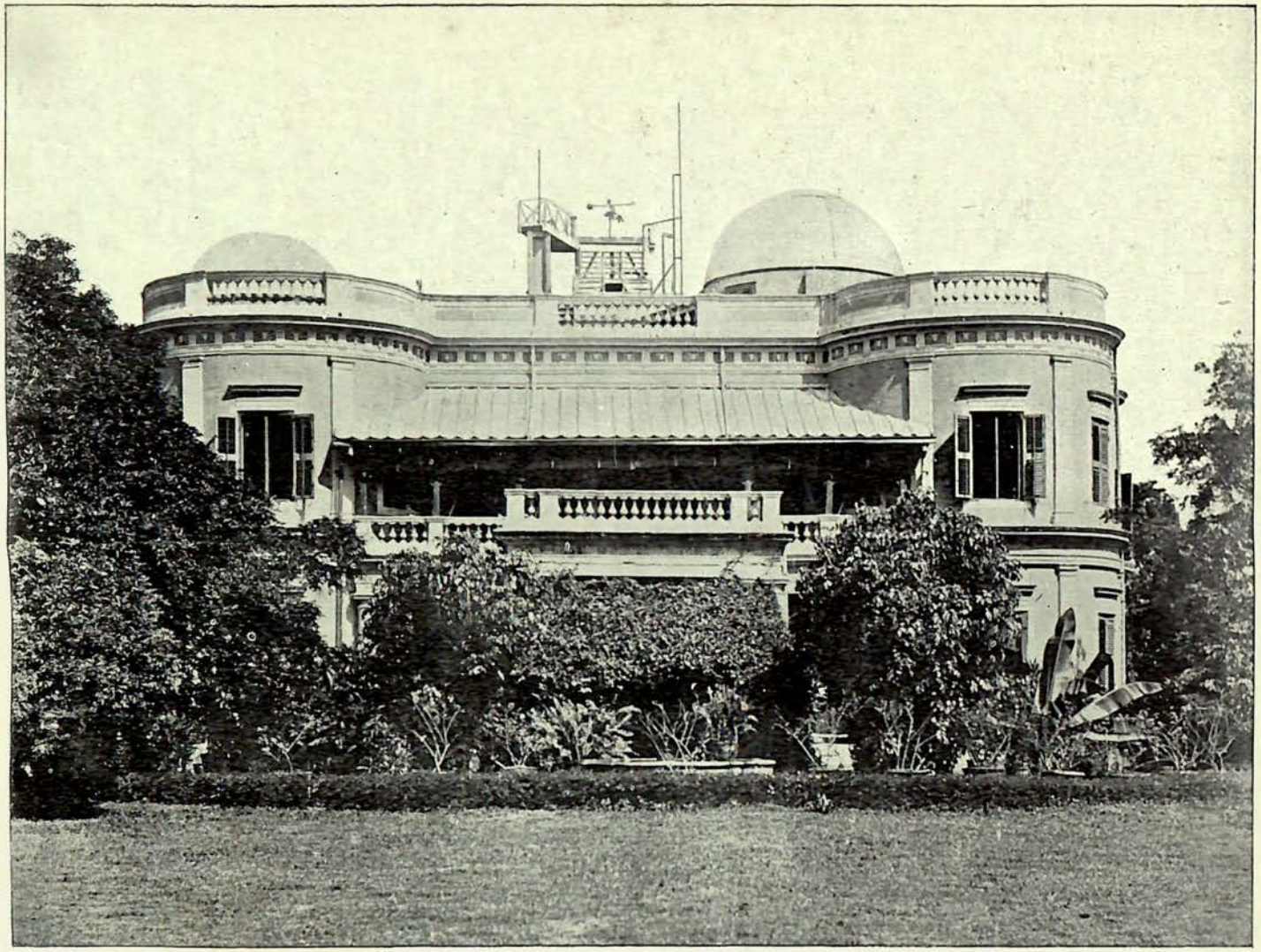
1926

BOMBAY BRANCH
OF THE
Royal Asiatic Society.



OBSERVATORY MADRAS
Founded 1788
(Newer part)

Report on the Administration of the Meteorological Department of the Government of India in 1925-26, and a Note on the Long-Established Observatories of Madras and Bombay.

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Last year saw the completion of the first half-century's history of the Department as an organised unit for India ; and the present year completes a whole century of history in the case of Bombay Observatory. But both these records are eclipsed by that of Madras, for the observatory there was established in 1792, 134 years ago, by the Hon. East India Company " for Promoting the Knowledge of Astronomy, Geography and Navigation in India ". Sir Charles Oakeley was then Governor of Madras ; he had been Assistant Secretary at 16,* an age when most present-day English boys have barely forgotten the feel of their knickers ; had graduated Secretary at 22, and proceeded Governor (with a baronetcy attached) at 39. In an age when the mental horizons of the Hon. East India Company's officers were heavily clouded by the pursuit of gain, and their hands busy in shaking the pagoda tree, he rose above his contemporaries in taking a keen interest in astronomy. So keen, indeed, was he, that without awaiting from the Court of Governors in London the approval for which he had asked, he established the observatory *ultra vires*, and when the actual sanction arrived in 1792, the building was complete and partly equipped.

Madras Observatory (see Plate).

In those happy days valuable initiative had free scope, for by the time objection could be raised an act had become a matter of history, and its author

*Lawson : " Memories of Madras ", page 117.

Report on the Administration of the Meteorological Department of the Government of India in 1924-25, and a General Survey of half a century's Work since the Establishment of the Department.

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THIS is the fiftieth Administration Report of the India Meteorological Department and records the completion of the first half century of systematic observations on weather in India, by uniform methods. It would have been pleasant to have been able to call 1925 a Jubilee year, but that would imply not only a 50 years' course of work, but a prosperous condition of the department at its close, with adequate staff and resources: it will be safer to call this year the half-centenary, and regard it as a fitting time to review the progress made, to take stock of the present and consider the future.

HISTORY.

2. In a country where extremes of climate—temperature, dryness and torrential rainfall—have always added to the difficulties of life, there must often have been a natural instinct to set up a collection of private meteorological instruments and take at least occasional readings. Even in the earliest days of British interest in India this was evidenced, for among the less unsystematic work of this kind there have been records by Colonel Pearse in Calcutta, 1785, and by other officers sprinkled about the country. But the difference is radical between any collection of short series of unordered observations and the work of a centrally controlled system on uniform lines, so that although before 1865 provincial authorities occasionally issued instructions to district administrative and medical officers to note temperatures, rainfall and air pressure, these old observations as actually taken have since been found to be of little value.

Sets of instruments were then issued, but without previous comparison with standards for determination of their errors, and commonly without instructions

was probably entitled to claim *De mortuis* exemption from censure. Such means of progress cannot be adopted nowadays, for Standing Finance Committees, cables, Secretaries of State, and other inventions of a later age place restrictive limits on peculiar action.

Oakeley's scheme was largely helped forward by the liberality of a member of the Madras Government—Mr. William Petrie—who some 5 years earlier had built an observatory at his private expense, the first ever instituted for astronomical purposes by a European in the East. The original building, (the transit-room of the present observatory) was erected with great care, every precaution being taken to secure the utmost possible stability for the instruments and durability for the structure. The pier which carried the original small transit instrument is a granite pillar weighing 2½ tons resting on a base of solid brick-work and separated from the foundations of the walls. On the top of this pier there is cut :—

Michæl Topping Arch.

A. D. MDCCXCII.

Michæl Topping was captain of E. I. C. Ship " Walpole " and was engaged in 1792 in taking observations of the currents in the Bay of Bengal. He became Chief Surveyor in Madras in 1794, and with the versatility which so conspicuously marked the Company's Officers in those days turned his hand to architecture when the need arose. On the south wall of the observatory is a slab bearing the following inscription :—

Astronomiæ Consecratum

Sumptibus Societatis Anglicanæ

In India Mercaturæ Faciendæ

Favente CAROLO OAKELEY Bar^to^

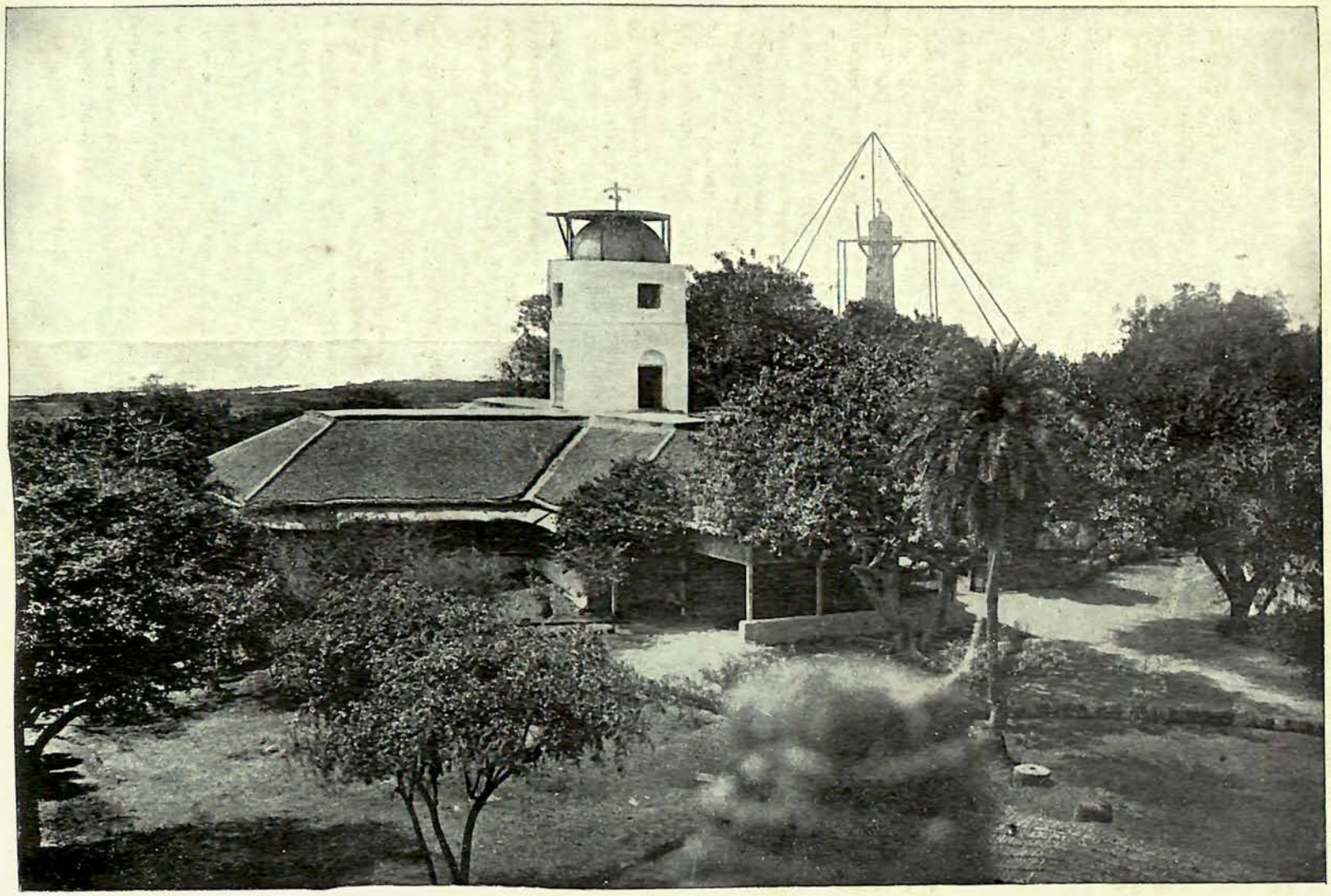
Præfecto Præsidii Sancti Georgii

A. D. MDCCXCII.

and somewhat corresponding inscriptions in Tamil, Telugu and Hindustani are carved on the granite pier in order that " Posterity may be informed a thousand years hence of the period when the Mathematical Sciences were first planted by British liberality in Asia ".

2. The first Astronomer was Mr. J. Goldingham, F.R.S., who also held the appointment of Government Architect. His earliest observations made in 1793 are recorded in a manuscript volume, now preserved in Kodaikanal Observatory, prefaced by an account of the building of the observatory, from which quotation has been made above. Two volumes contain his observations between 1812 and 1825, and another contains an account of his very valuable pendulum observations made near the equator and at Madras. He also made longitude determinations of a number of stations in India and elsewhere, a long series of observations on the velocity of sound by means of the Fort and Mount time guns, and he began a meteorological register in 1796.

He was followed by Mr. Thomas Glanville Taylor, F.R.S., who had been trained at Greenwich Observatory and held charge of Madras observatory from September 1830 till early 1848. He equipped his observatory with new and more powerful instruments and began the compilation of his Star Catalogue which, in its final form, was published in 1844, and contains the places of 11,000 stars. This catalogue is still asked for, and was reprinted some 20 years back. Hourly meteorological and magnetic observations were begun in 1840 by Captain S. O. E. Ludlow, and transferred to the observatory in 1845, when the buildings were considerably enlarged.



COLABA OBSERVATOR BOMBAY.
Founded 1826 ; Photogaphed 1877.

From 1849 to 1861 the appointment of Astronomer was held successively by Captain W. S. Jacob, Major W. K. Worster and General J. F. Tennant, R.E., and then for 30 years by Mr. N. R. Pogson, who was joined in his work by his wife and daughter, the latter of whom held also for many years the appointment of Meteorological Reporter to the Government of Madras.

After 1861 the observatory was again furnished with modern instruments of a high class, the chief being a transit circle and an 8-inch equatorial ; and during Mr. Pogson's tenure the transit circle was employed for the preparation of a catalogue of 5,000 stars, each of which was observed at least five times. With the equatorial Mr. Pogson discovered six minor planets and seven variable stars, and continued his work on an atlas of variable stars. Mr. Pogson died in 1891 before the observations for the catalogue had been completely reduced or published, but that work was completed by his successor, Mr. Michie Smith, who remained Government Astronomer at Madras until 1899.

3. For some years before this it had been recognised that the equipment of the observatory had again become inadequate, and that Madras was unable to undertake any work in the newer fields of spectroscopic and photographic astronomy. The question then arose of what the future work should be, and where the new equipment should be located—at Madras or at one of the hill stations where a clearer and steadier atmosphere and better observing conditions would be obtainable. It was eventually decided (1893) to locate this part of the Madras Observatory at Kodaikanal, and to furnish it with new instruments for the spectroscopic study of solar phenomena and changes, and for detection of any solar influences on terrestrial phenomena—more particularly their influence on monsoon strength and its distribution, with their corollary, the incidence of famine. The present observatory at Kodaikanal, started by Mr. Michie Smith, continued by Mr. Evershed, F.R.S., and now directed by Dr. Royds, is the result of that decision, and a systematic study is now being made there by daily observations of the sun's surface ; the work is done in co-operation with other observatories similarly equipped in other parts of the world.

4. In 1899 Mr. R. Ll. Jones, Professor of Physics, Presidency College, Madras, was appointed Meteorologist, Madras, and did valuable work in that capacity. He published three important papers in the departmental memoirs, Professor Jones retired in 1919 and in 1921 was followed by Dr. S. R. U. Savoor, also of Presidency College.

Colaba Observatory (see Plate).

5. It was in the year 1823 that the present site of the Colaba Observatory was selected and the ground enclosed under the direction of the East India Company. The main building was erected in 1826 under the supervision of Mr. Curnin, the first Astronomer at Bombay, and during the year now under review completed a century of its existence. The first fifteen years of the observatory's operations were marked by a period of inactivity, for the instruments supplied to Mr. Curnin were found to be defective and had to be shipped back to England. In 1835, the Observatory was assigned as a dwelling house to Mr. Orlebar, Professor of Astronomy in the Elphinstone College, and although a few instruments were placed at his disposal, no meteorological or magnetical observations taken before 1841 are on record. On the recommendation of the Royal Society systematic observations began in that year, and the Observatory was associated in research on meteorology and magnetism (besides continuing its astronomical work) with the colonial observatories of Toronto, Hobarton, St. Helena, Singapore, the Cape of Good Hope, and with the Indian Observatories at Simla and Madras. From this year the active life of the Observatory may be said to have begun. In 1842, Mr. Orlebar was succeeded by Dr. Buist, but the appointment of Astronomer at the Observatory was subsequently held by officers of Her Majesty's Navy stationed at Bombay. This arrangement continued till 1864,

during which period continuous records of astronomical, magnetic and meteorological observations were secured. But the work was not wholly satisfactory ; the generally defective condition of the equipment of the Observatory resulted in the appointment by Government of a committee of enquiry which, after a full investigation, recommended that (*a*) a full equipment comprising the latest type of recording instruments should be procured, and (*b*) a full-time and fully qualified officer should be appointed as Director. These recommendations were at once acted upon, and Mr. C. Chambers, F.R.S., was appointed in 1865 as the first Director. The change then made has more than fulfilled the expectations of usefulness for the Observatory, which now ranks as a first class Institution with a well-established reputation in the scientific world. Both the magnetic and meteorological branches were, as recommended, fully equipped with photographic and mechanically self-recording instruments and with other auxiliary instruments for eye observations. The activity of the Observatory under Mr. Chambers' régime is apparent from the papers published by him in scientific journals, and by the volumes issued from the Observatory during the years 1865 to 1894, which contain valuable contributions to science. On the death of Mr. Chambers in February 1896, Dr. N. A. F. Moos was appointed to fill the vacancy.

6. Later in 1896, Sir John Eliot recommended to the Government of India that Colaba Observatory, till then under the Government of Bombay, should be transferred to the jurisdiction of the Imperial Department with the Government of India ; that the Director should reside in Kodaikanal and there do his work of analysis and memoir-writing on the Colaba records, and that the officer in charge on the spot should be a half-time Superintendent holding professorial duties at some Bombay College.

In 1898 Sir Norman Lockyer was deputed by the Secretary of State to visit India and report upon various observatories and their work. Subsequently the imperialisation was effected, but the division of duties between a non-resident Director and a resident superintendent was not adopted, and the Director remained on the spot.

In 1898 a seismograph was obtained and set up, to take part in the programme of observations started by the Seismological Committee of the British Association.

7. Early in 1900 the city of Bombay decided to electrify its street tram service, and it became necessary to remove the magnetic work from Colaba to a place free from artificial disturbance. A new Magnetic Observatory was consequently built at Alibag some 18 miles to the south-east of Bombay, a distance which was considered sufficient to secure the needed immunity, but still small enough to retain generally similar magnetic conditions and so to continue the record of Bombay measurements. The site was secured in 1902, the buildings were completed in 1903, the observatory was equipped with a full set of new magnetic instruments, and comparative observations began in April, 1904.

During the next two years, and before the electric tramways were put into actual commission, undisturbed duplicate records were obtained at Colaba and Alibag for comparison purposes, and the magnetic work at Colaba was then permanently closed in March 1906. By that time Colaba had the creditable record of more than 60 years of continuous magnetic records, and in 1910 Dr. Moos, the Director, published a comprehensive study of the whole, for the period 1846 to 1905, under the title " Colaba Magnetic Data ".

Dr. Moos retired in 1919, and the Directorate was assumed in 1920 by Mr. T. K. Chinmayanandam and in 1922 by Dr. S. K. Banerji.

8. A few years after the appointment of Mr. C. Chambers as Director of the Observatory, the Government of Bombay created the post of Meteorological

Reporter to the Government of Bombay, and located this officer and his staff at the Observatory. Mr. Frederick Chambers became the first Reporter, and associated himself with Mr. C. Chambers in meteorological and magnetic investigations. In 1888 the post of meteorological reporter was reduced to a half-time appointment and placed under the control of the Imperial Meteorological Reporter. The local Superintendent of Telegraphs was appointed in this post, the meteorological office being transferred to the Telegraph buildings. This arrangement remained in force till April 1923 when the weather duties were returned to Colaba Observatory, the half-time post of the Meteorologist was abolished, and the weather office amalgamated with that of the Director, Bombay and Alibag Observatories, who was thereafter designated as ' Meteorologist, Bombay '.

9. The operations of the observatories at Colaba and Alibag are directed first to enquiry into the sciences of terrestrial magnetism, meteorology, and seismology ; secondly, to the publication of recorded facts and observations, their reduction and discussion, and to the distribution of publications amongst learned societies and men of science in all parts of the world ; and thirdly, to astronomical observations for the purposes of timekeeping, the signalling of time for the purposes of navigation and the rating of marine chronometers. With these objects in view, the observatories are equipped with various magnetic, meteorological, astronomical and seismological instruments installed in separate buildings, suitably constructed for their accommodation.

The routine operations of the Observatory and Meteorological Office consist in maintaining in continuous action the autographic instruments (magnetic, meteorological and seismographic) ; taking eye observations five times a day of the absolute instruments ; taking a regular series of observations to determine the absolute values of the various magnetic elements ; reducing the data thus secured and putting them into the proper form for publication and investigations ; publishing a daily weather report ; collecting data for marine meteorology ; supplying climatological, magnetic and seismic data and reports to several officers and men of science, and furnishing the requisite information on magnetic, meteorological, seismological and other allied questions to Government Officers and others. In the astronomical section the observations of stars and sun are made with sufficient frequency for the correct rating of the large number of chronometers kept in store for issue to ships of the Royal Indian Marine and the Royal Navy, and for directing the falls of the time-signal balls on the towers at the Castle and Prince's Dock. Wireless time-signals from the various time transmitting stations, particularly Eiffel Tower and Nauen, are regularly received in the observatory and used as a check on the determination of local time.

The principal publications which have been issued by the Observatory are :—

(1) Bombay Magnetical, Meteorological and Seismographic Observations ; 42 volumes.

(2) Meteorology of the Bombay Presidency.

(3) Colaba Magnetic Data ; 2 volumes.

(4) Magnetic Disturbance Charts, 1905-1915.

(5) Rainfall in the Bombay Presidency ; 6 volumes.

(6) Numerous papers published in the Proceedings of the Royal Society, Philosophical Transactions of Royal Society, Philosophical Magazine, Terrestrial Magnetism and Atmospheric Electricity, Nature, etc.

REPORT ON THE ADMINISTRATION OF THE METEOROLOGICAL DEPARTMENT OF THE GOVERNMENT OF INDIA IN 1925-26.

CHIEF FEATURES OF THE YEAR.

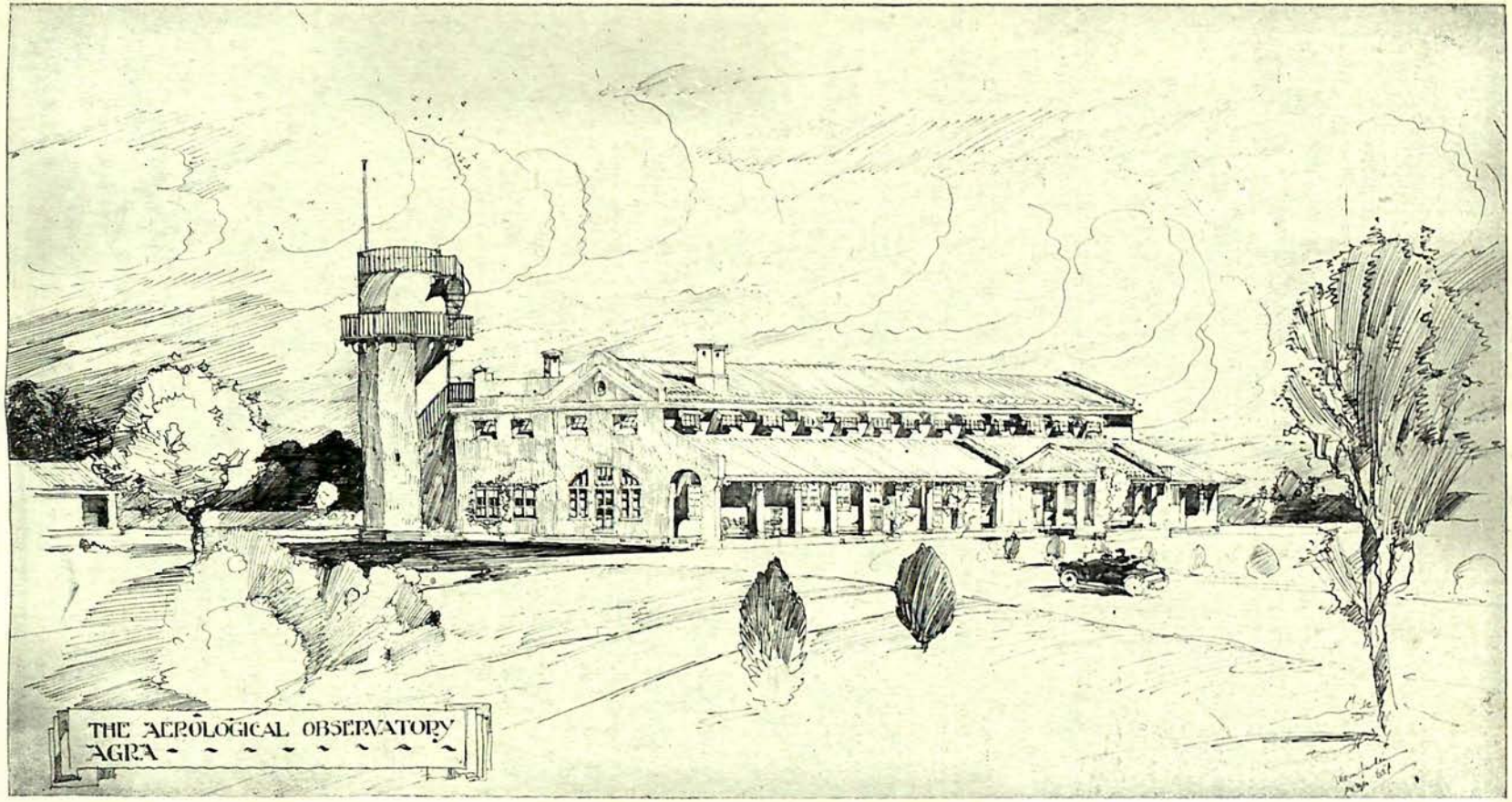
10. In the year under review, the first of the Department's new half century, it became necessary to propose to Government various internal changes bearing on further development with utilitarian objects. That changes to allow of extended practical activity were called for, had been independently evidenced by the critical interest in the department shown during the year by Chambers of Commerce and the responsible Press of the country. A resolution of the Associated Chambers, at their meeting in December, outlined the Chambers' views as to present meteorological needs, and their views coincided closely with those of the department itself : while with regard to the Press, it was very noticeable throughout the year how frequently was voiced the public realisation that the time had come to provide adequately for essential advance. It has come, in fact, to be generally recognized that if the Meteorological Department cannot claim to be a revenue-producing body, it is incontestably revenue-saving, and that with suitable official support it would rapidly justify the allotment of a greatly increased budget.

In regard to this support it is gratifying to be able to record that Government have recently approved in principle the proposals put forward for early extension, and the department wishes to express the greatest appreciation of the helpful interest now shown officially in the desired new developments. As first fruits of the approval referred to, sanction has been received for an immediate small increase of staff, with a promise of early consideration for action on the remainder of the programme in view. The staff increase will admit of a first step towards provision for adequate treatment of marine meteorology, improvements in daily forecasting, analysis of accumulated upper-air data, and the better care of departmental instruments.

11. Shortly before his retirement Sir Gilbert Walker pointed out to Government that statistical methods of forecasting, using ground level data, had been developed, and given a full chance, in the course of 48 years of work in Simla ; and that as such methods had shown limitations, the time had come to use in addition all other available means of improvement. The processes at work in the atmosphere being essentially physical it was necessary to take actively in hand the measurement of characters of air currents throughout their depths by means of balloons and recording instruments ; and as for such physical work generally the location of the headquarters office in Simla was unsuitable, removal to the plains had become advisable.

Sir Gilbert Walker agreed, in fact, with his officers in regarding an active experimental programme as essential at the present stage, and Government have now given their emphatic approval to this view. They have promptly granted an initial monetary allotment in the budget for 1926-27, and a start is to be made at once by acquisition of land at Poona, and preparation of building plans and material.

12. Three several schemes in connection with the supply of weather information to aviators received attention during the year. One concerned the Royal Air Force squadrons on the frontier, for whom the R. A. F. appointed two British meteorologists to start local forecasting centres at Quetta and Peshawar respectively. In view of the advantage of concentrating all meteorological arrangements as far as possible under one authority, and in return for the useful information which these officers will be able to supply, this department placed at their disposal the necessary equipment, as well as telegraphic information from observatories in Persia and north-west India.


THE AEROLOGICAL OBSERVATORY
AGRA

The two other schemes, still in the stage of examination, concern the share which India will take in the supply of meteorological information to airships and aeroplanes on the Egypt-Karachi route. Airships may follow alternatively the Persian Gulf and Red Sea routes, according to the prevailing or seasonal flow of the upper winds ; and for the airship service India has been asked to undertake the cost and responsibility of providing weather information in the area roughly represented by the triangle Karachi-Aden-Basrah, a region singularly poor at present in communications, and in conveniences for starting and maintaining upper-air observatories. It will be recollected that a disastrous storm occurred in October last in the Persian Gulf, and did great damage to pearling boats and date plantations : such a storm might well spell destruction to an unwarned airship, but so open is the present meteorological network in those regions that the indications afforded on weather maps of what was to take place there were practically *nil*. Forecasting for airships from a centre at Karachi will therefore involve considerable expenditure, and call for a very knowledgeable choice of programme.

13. The upper-air researches of the department, which centre round the observatory at Agra, (see Plate), were carried on throughout the year by measurements of high level winds at Agra and eight outstations. The expedition to Jask at the entrance of the Persian Gulf completed its year's useful observations of upper winds there ; and a new station was opened at Karachi, partly to provide needed information to aviators of the R. A. F., and partly in preparation for the Airship and Aeroplane services which are expected to be operating within two or three years.

The Agra results have already been found to bear close application in daily weather forecasting ; and they promise now to be of practical use for seasonal forecasts, possibly a still more important purpose. During the 12 years for which data are available a close relationship has existed between the strength of westerly winds in the air-stream between 4 and 8 km. above Agra in September and October, and the subsequent winter precipitation in north-west India. The relationship has a physical basis, for the high-level winds in Agra first begin in September to assume their winter characters, and it is in these winds that the rain-bearing storm-centres of the cold weather travel eastward from the Mediterranean. There have further been found hopeful indications in the hot-weather upper-winds at Agra and Bangalore for forecasting monsoon rainfall. Many further years' test-data will be required before these tentative conclusions can be accepted, but meanwhile the department believes that the opening of several more upper-air stations over India and Burma, as well as at Port Blair, Aden and Seychelles, would bring results thoroughly justifying the expenditure involved.

Quite apart from potential use in seasonal forecasting, an extension of this work is needed. Improvement in the practice of warning for cyclones calls now for much more knowledge of upper-air currents than exists to-day in Indian regions, and it is further essential not to be found materially wanting in preparedness when the safety of aircraft in a few years' time shall draw attention to any lack of present foresight.

14. During the year the services of storm-warning to ports and shipping and of flood warning to officers in the Irrigation, Railway and other departments, were carried out from Simla, and were as satisfactory as circumstances allowed. Warnings for the Arabian Sea were issued on 21 occasions, one for a storm and the others mainly for depressions or for squally weather due to advances of monsoon. For the Bay of Bengal warnings were issued for 31 periods of disturbed weather, of which four developed into moderate storms and one into a severe cyclone.

On the general question whether storm-warning for the Bay of Bengal should continue to be dealt with in Simla or should revert to Calcutta (under adequate staff for the first time), Government decided in favour of the latter, and two officers, one of whom had been under intensive training to prepare him for the work, were transferred to Calcutta in March, and are to be followed by a third officer newly to be appointed. Apart from this work of storm-warning, it is expected that very solid advantages in the efficiency of Alipore Observatory will be gained from the change, which replaces a single part-time officer, necessarily absent on college duties for the greater part of each day, by trained personnel with their whole-time available for the work of the observatory.

It was mentioned last year that an attempt to secure " touch " with ship-captains in the Bay had been made by supplying on personal loan reliable instruments for shipboard use, and that two barographs were in that way in operation on the Madras-Rangoon run. The intention is to extend this practice considerably, and it will now be possible for the new storm-warning officers in Calcutta to give attention to the matter. Fully effective action must, however, await the appointment of the Marine Meteorologist, for there is much work attached to the system of loan of such instruments : its purpose is not gained unless prompt and critical attention is given to the instrumental records, and unless appreciation is shown of the services of commanders in working the instruments efficiently. The appointment of this officer is under consideration by Government.

15. Allusion had to be made in the report for 1924-25 to the enforced cancellation of some of the points of retrenchment which had been impressed upon the department in an earlier year. Public opinion, and the insistent demands of such well-informed bodies as the Bengal Chamber of Commerce, had shown that, in the attempt loyally to meet the call for retrenchment, more had been undertaken than had been advisable. In the year just past this reaction had to go further ; the Madras Daily Weather Report has returned to its original practice of issue throughout the year, and the Bombay report has resumed an additional month, so that it now appears from May to November inclusive.

16. In matters of publication a paper on the storms of the cold-weather, by Sir Gilbert Walker and Dr. Kumeshvar Rav, was issued during the year, and there were under preparation or in the press an issue of revised normals of meteorological elements at departmental observatories, and a set of tables of monthly rainfall in geographical divisions and sub-divisions covering the last 50 years. An Atlas of Storm Tracks in the Bay of Bengal, based on the history of the last 33 years, was published by Dr. Normand and a volume giving the magnetic, meteorological and seismographic observations made at Bombay during 1916-20 was published by the Bombay observatory in January.

Leave and appointments.

17. Mr. S. Sitaramayya, B.A., Assistant Meteorologist, was transferred from Agra to Simla, and Mr. Barkat Ali, M.Sc., from Simla to Agra. The former made over charge of his office to Mr. Barkat Ali on the 21st April 1925, and joined the Simla headquarters three days later.

Mr. S. Sitaramayya, was granted leave on average pay for one month and 8 days from the 22nd June 1925, and in continuation leave on half average pay for 26 months and 22 days. Mr. Mukand V. Unakar, B.A., was appointed to act as Assistant Meteorologist during his absence.

Mr. M. V. Unakar reverted to his post of Superintendent in the Simla Meteorological Office from the 17th August 1925 and Mr. Hans Raj Puri, M.Sc., an Assistant in the Simla Meteorological Office, was appointed to act as Assistant Meteorologist with effect from the same date, *vice* Mr. Sitaramayya on leave.

Mr. Hans Raj Puri reverted to his post of Assistant in the Simla Meteorological Office from the 21st September 1925. Mr. F. M. Shuja, M.Sc., an Assistant in the Simla Meteorological Office was appointed to act as Assistant Meteorologist with effect from the same date, *vice* Mr. Sitaramayya on leave.

Mr. F. M. Shuja reverted to his post of Assistant in the Simla Meteorological Office from 1st October 1925, and Mr. M. V. Unakar was appointed as Offg. Assistant Meteorologist from the same date, *vice* Mr. Sitaramayya.

Mr. V. V. Sohoni, B.A., B.Sc., Meteorologist, Simla, after return from leave for 30 days, resumed charge of his duties at Simla from the 20th April 1925.

Mr. V. Doraiswamy Iyer, B.A., Assistant Meteorologist, on return from leave for 3 months and 12 days reported himself for duty at the Madras Office from the 8th June 1925.

Dr. S. N. Sen, Ph.D., M.Sc., was appointed on probation to be a Meteorologist in the Indian Meteorological Department with effect from the 14th September 1925.

Dr. K. R. Ramanathan Iyer, M.A., D.Sc., Lecturer, at University College, Rangoon, was appointed to be a temporary Meteorologist in the Indian Meteorological Department and posted to Simla Office with effect from the 2nd October 1925.

Dr. B. N. Banerji, M.Sc., Ph.D., was granted leave on average pay from the 11th September, 1925 to 7th October, 1925.

Mr. G. Chatterjee, M.Sc., Meteorologist, Upper Air Observatory, Agra, was granted leave on average pay for two months with effect from the 12th October 1925.

Dr. S. K. Banerji, D.Sc., Meteorologist, Bombay, was granted leave on average pay for 3½ months with effect from the 16th December 1925.

Dr. T. Royds, D.Sc., Director, Kodaikanal Observatory, returned to duty, after leave for 13 months, on the 18th December 1925.

Mr. Barkat Ali who had been appointed on probation to the post of Assistant Meteorologist with effect from the 16th April 1924, was confirmed in his post from the 21st December 1925.

Dr. S. N. Sen was granted leave on average pay for 6 days with effect from the 28th December 1925.

Dr. B. N. Banerji was posted to Agra from 8th October to 2nd December 1925 and to Bombay from 14th December 1925 to 8th March 1926. He returned to Simla on the 15th March 1926.

Dr. K. R. Ramanathan was posted to Bombay with effect from the 4th March 1926.

Dr. C. W. B. Normand, M.A., D.Sc., Meteorologist, Simla, went on leave on average pay for eight months with effect from the 29th March 1926.

The system of storm warning for ports and shipping.

18. The work of warning ports and shipping in the Arabian Sea and the Bay of Bengal of the approach of cyclonic storms, or of bad weather, was done throughout the year from Simla. Thirty-two ports are on the warning list for storms in the Arabian Sea, and thirty-eight ports, fourteen River Police Stations and thirty-nine District Police stations for storms in the Bay ; of the Bay ports, twelve get additional information regarding the particular areas in which weather is disturbed, a special system of ' locality signals ' being in use for this purpose. Shipping at sea is also supplied with the latest weather information by means of wireless bulletins, which are broadcasted twice daily, or more frequently if the occasion demand it, from the radio stations at Bombay, Karachi, Calcutta, Rangoon, Madras, Matara (Ceylon) and Aden. An account of the warning system as it stood in 1918 may be found in the " Code of Storm Warning Signals for use at Indian Ports," obtainable at Calcutta from the Superintendent of Government Printing India ; but additions to the extent of the warnings have been made since.

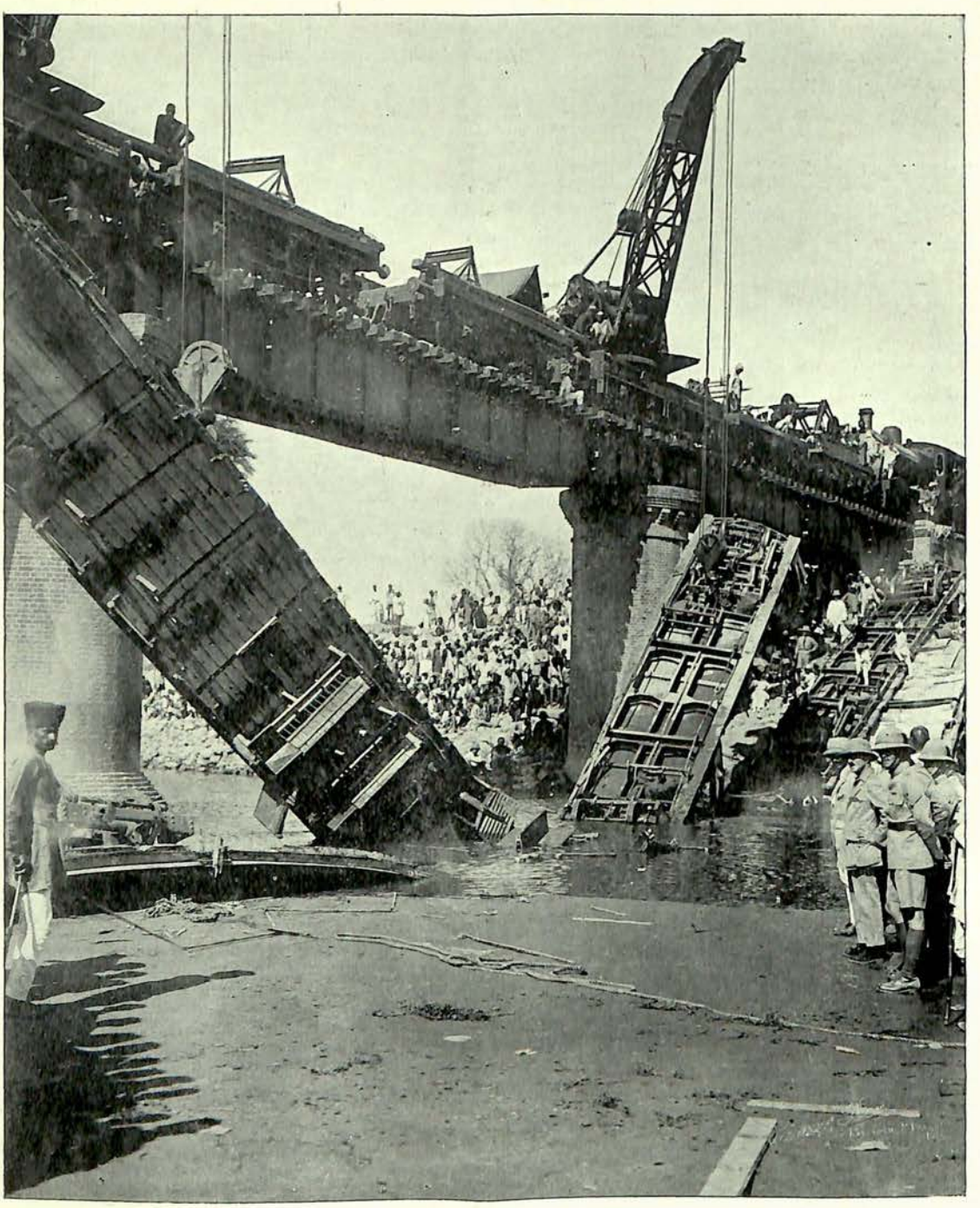
Warnings for storms or disturbed weather issued to ports and shipping in the Bay of Bengal.

19. During the year warnings were issued for 31 periods of disturbed weather ; the disturbances developed into moderate storms during four of these periods, and into a cyclone once. This last storm was generated in the neighbourhood of the Nicobars on the 10th May. The 8 hrs. observations of the 11th showed a marked fall of pressure at Port Blair and a fairly definite circulation of wind round an area of low pressure south or south-east of Port Blair. By the morning of the next day a definite depression had formed with centre near Lat. 11° N., Long. 19° E.; it continued to intensify and by the morning of the 14th had become a severe storm of small extent with centre near 13° N., 85° E., the area of stormy winds being of diameter about 150 miles. The storm developed still further, and, after passing through 14° N., 82° E., at 20 hrs. on the 15th altered its course towards the north and crossed the coast a little north of Masulipatam shortly after noon on the 16th. Thereafter it weakened to a depression and advanced north-eastwards parallel with the coast line without further weakening until it reached Assam, where it disappeared on the 20th. The storm was of the very violent type which has a calm centre, and the deficiency of pressure in the central area was at least 1.5″. It was noteworthy for the circumstance that although its point of crossing the coast did not lie actually in south Madras it was the first storm since 1888 to have in May a track across the Bay towards that coast. In the Godavary and Kistna districts it caused extensive damage to buildings with some loss of life and a dislocation of railway and telegraphic traffic ; hundreds of cattle also were reported to have been drowned.

Warnings for storms or disturbed weather to ports and shipping in the Arabian Sea.

20. The west coast ports are warned not only for storms but also for squally weather, especially at the beginning of the monsoon. There were 21 periods of disturbed weather for which warnings were issued : during 15 of these the warnings were for squally weather or strong winds connected with the monsoon, during 5 for rough weather off the Mekran coast due to the passage of western depressions through Baluchistan, and during the remaining one for a storm which struck the Malabar coast in November. This storm had its origin in the south-east of the Bay of Bengal. Unsettled conditions appeared in this region on the 3rd November and, advancing westwards, developed into a depression off the east coast of Ceylon by the morning of the 6th. The depression was over Ceylon on the morning of the 7th, and later passed into the Arabian Sea ; at 8 hrs. on the 9th it was a storm of small extent with centre about 2° west of Cape Comorin. Its track then became practically northerly and it crossed the coast near Tellicherry on the night of the 10th-11th. The warnings to ports other than Calicut and Tellicherry were satisfactory. There was only one ship's message on the 10th from the sea area, and that one was some considerable distance from the storm and afforded little help ; but the log of the S. S. " Japan ", subsequently obtained, showed clearly that if a message had been received from that ship to give any one of the three sets of observations logged at 10 h., 12 h. or 16 h. on the 10th September in the immediate vicinity of the storm, the sharp change of storm track would have come to light, and the probability would have been clear of the storm striking the coast. In that case the " distant warning " signals which had been hoisted along that coast could have been changed to " local danger " signals in good time.

21. The number of warning messages for ports and the two sea areas issued by the department during the year was 5,149. These messages consist of radio weather broadcasts from the wireless stations at Rangoon, Calcutta, Madras,



Tornado destruction: train blown off bridge.

Matara, Bombay, Karachi and Aden, and of warning messages during storms or periods of disturbed weather to coastal ports on the Bay of Bengal and the Arabian Sea.

22. Reports on the working of this marine warning system were received from 33 officers on the warning lists ; of these, 31 stated that the warnings were satisfactory or gave no remarks, and the remaining 2 offered criticisms which received prompt consideration. Of the criticisms offered, the one from the Deputy Conservator of the Port, Rangoon, complained that local warnings were not issued in respect of the storm experienced at Rangoon on the 15|16th October. At the time of this storm another and greater disturbance was developing off Masulipatam, to last several days and traverse the Bay to the Burma coast near Cox's Bazar. The smaller storm was, on the evidence available, a mere depression on the 15th and unlikely to develop seriously : of this notice was given to Rangoon. By the next morning it had passed inland and shown that its winds were stronger than the evidence had indicated. It may be remarked that subsequent examination of the logs of S. S. " Jalvihar " and " Tilawa " showed that if those ships had telegraphed their logged data on wind direction and strength the true state of the case would have been known, and warnings would have obviated the damage that actually occurred in Rangoon river.

The second criticism was from the Port Officer, Tellicherry, who objected that the " distant warning " and not the " danger " signal was hoisted during the cyclonic storm which passed over the port between 4 A.M. and 7 A.M., on the 11th November 1925. The reason for this has been shown above to have been the complete lack of observations from the sea area near the storm.

FLOOD AND STORM WARNINGS, AND WEATHER FORECASTS TO DISTRICT, IRRIGATION, RAILWAY AND OTHER OFFICERS.

23. This work was done wholly by the Simla Meteorological Office. The organisation for warnings is a development of many years' practice, and its details differ considerably in character, according to the nature and extent of the flood or weather warnings required by those concerned. In most cases the officers require telegrams either warning them of advancing storms likely to give heavy rain or informing them of the actual occurrence of heavy rainfall likely to cause severe floods which may injure railways or canal works ; in other cases they require warnings or forecasts of the weather for as long a period beforehand as is practicable.

At the end of the year there were 199 addresses in the listed number of district officers and officers in the irrigation, railway and other departments to whom flood warnings, weather forecasts, and intimations of the likelihood of rain during the dry season were to be sent by this department. There were also 19 officers of the Telegraph Department requiring warnings, mostly for strong winds.

In order to provide against serious loss of life and property in inland Bengal when a cyclone from the Bay crosses the coast, 461 officers were added in 1921 to the warning list ; of these officers 40 hoist the signals shown in Appendix D of the " Code of Storm Warning Signals " whenever instructed to do so.

The number of special inland forecasts and warning messages issued by the Department during the year was 1,555. and in addition 850 telegrams of actual heavy rainfall were sent by meteorological observers direct to various officers.

Reports on the working of this system of inland warnings were received from 26 of the officers on the warning lists. Of these, 22 stated that the warnings were satisfactory or gave no remarks, and the remaining 4 offered suggestions or minor criticism, which have received consideration.

On the whole a comparison of the inland warnings with the actual subsequent rainfall, or the tracks of storms across country, show that the system is working satisfactorily and that most of the warnings issued were of value to the recipients. Examples of damage by storm and flood are shown by two plates of illustrations herein.

Warnings of disturbed weather to military authorities and aviators.

24. Telegraphic forecasts of the likelihood of bad weather, required by the Military Headquarters, Waziristan, in the first two months of the year were stated to have proved accurate and of utmost value for military operations. Special warnings were several times issued to the General Officers Commanding-in-Chief, Northern Command, Rawalpindi, and Eastern Command, Roorkee, and also to the G. O. C., Peshawar District.

From time to time telegraphic weather warnings were supplied to various aviators, and it is satisfactory to note that almost invariably the forecast were reported to have been correct and useful.

The following appreciation, dated 27th May 1925, of the department's warnings, received from Headquarters, Royal Air Force, Peshawar, is of interest :—

> "I should like to record the fact that the weather reports issued from the office of the Director-General of Observatories, Simla, during the recent operations in Waziristan and since, especially those issued in connection with the flight of aeroplanes from Risalpur to Srinagar during the past week, have been of the utmost value.
>
> The success of the flight to Srinagar rested to a great extent on the accuracy of the weather reports received ; that issued from your office enabled the flight to be carried through without interference from inclement weather, and in spite of local adverse reports."

The Chief of the Air Service, War Department, Washington, wrote with regard to the American world flyers :—

> "The flight of the United States Army Airplanes which set out to encircle the world on April 6, 1924, succeeded in completing its undertaking September 28, 1924. It is realised that only through the aid and co-operation given these airmen along the route were they able to make the expedition a success. The reports of the members of the flight and the officer who made the advance preparations speak highly of your aid.
>
> I wish to express to you my sincere thanks and appreciation for your assistance which has played such a large part in making the first airplane flights around the world a reality".

ORGANISATION FOR IMPROVED WEATHER SERVICE TO ROYAL AIR FORCE.

25. Opinions had for some time been agreed that the available supply of meteorological information to the R. A. F. on the frontier was inadequate, and that the minimum requirement was the posting of a competent meteorologist at Peshawar and another at Quetta, with necessary staff, instruments, stores and daily telegrams to enable them to make detailed forecasts ; and it was judged that their daily telegrams should include pilot balloon observations from the R. A. F. stations at Karachi, Quetta, Dardoni, Peshawar, Lahore and Ambala.

With a view to give effect to these proposals, F./Lt. R. G. Veryard and F./Lt. R. P. Batty were appointed with *pro forma* R. A. F. commissions as Meteorologists for the Royal Air Force, and in November 1925 were stationed at Peshawar and Quetta respectively. These two officers are under their respective commanders for disciplinary purposes, but their technical work is supervised by the Director General of Observatories. They issue general accounts and forecasts of weather over the area Delhi-Peshawar-Quetta-Karachi,

Flood destruction : line breached.

and detailed local forecasts and warnings, each for his own immediate neighbourhood. The organization to accomplish these aims provides for :—

(*i*) A daily composite message from Simla at about noon to each of these officers, embodying in code all the morning observations received from observatories in the Punjab, Sind, the Frontier Province and Baluchistan.

(*ii*) Afternoon observations from selected stations in Baluchistan.

(*iii*) Afternoon observations from stations in Persia and Arabia.

(*iv*) Upper air observations from Karachi, Lahore, Peshawar, and Quetta : with Ambala and Miranshah as soon as arrangements can be completed.

(*v*) Such other weather information as can be arranged for from other aerodromes and military stations in N.-W. India.

Supply of meteorological information.

26. From time to time special information is supplied to the meteorological departments of England, Australia and Egypt. Climatological and other data, at times involving special calculations, are also provided for sanitary and other officers of Government as well as for those private firms who are willing to pay for the service. The extent to which the department was utilized in this manner during the last year will be seen from the curves B and C in the graph at the end of this report.

Observatories.

27. *Agra* : *Upper-air.*—Exploration of the free atmosphere in India has been recognised as indispensable in the interest of aviation, general meteorology, and both daily and seasonal forecasting. The recognition found its expression in the orders issued by Government in April, 1924, placing Agra Observatory on a permanent footing, and also in recent orders sanctioning a second meteorologist for the observatory and some increase in the staff. The principal routine work of the year at the observatory consisted, as before, of—

(*a*) supplying material and equipment to the upper-air stations at Quetta, Peshawar, Karachi, Lahore, Simla, Diamond Harbour, Akyab, Poona, Bangalore and Port Blair,

(*b*) exercising close supervision over work at out-stations,

(*c*) tabulation of pilot balloon results and of cloud observations,

(*d*) flight of instrument-balloons ; 50 were sent up and 28 recovered,

(*e*) repairs to barometers and anemometers,

(*f*) construction of Stevenson screens, 50 of which were made and sent to various observatories and private institutions.

A new 30-B.H.P. paraffin engine, a hydrogen compressor, a new battery of 600 ampere-hour capacity, and a new electrolyser capable of producing 100 cubic feet hydrogen per hour, were installed in the new engine house, the construction of which was completed in February 1925.

The temporary station at Jask, which was opened on the 4th June 1924 to collect upper-air data in an unsurveyed part of the Imperial air route, and also to throw some light on the physical causes of breaks in the monsoon, was continued to secure a whole year's history, the observations made in the previous year having been found to be of considerable importance. Towards the end of the year, on March 14th, an upper-air station was started at Port Blair. A

knowledge of the upper winds at this station, apart from its usefulness for storm warning purposes, is expected to give valuable indications of the oncoming Bay monsoon.

To arrange for a supply of more adequate information to the two R. A. F. Meteorologists, stationed at Quetta and Peshawar, it was decided to transfer the upper-air station at Simla to Ambala and to open a new station at Dardoni, but this could not be given effect to during the year. A new station was opened at Karachi, in August 1925.

28. At the request of the Air Ministry, arrangements were made to expose different samples of airship fabrics, supplied from the airship works at Cardington, to Indian climatic conditions, and Agra was selected as a suitable station for carrying out this test. A report on this exposure was drawn up and sent to the Director of Airship Development, Cardington, and this appears to have met with great appreciation there.

The Agra Observatory, as usual, supplied equipment for pilot balloon work at 8 artillery practice camps during the winter.

29. *Bombay.*—The routine activities of the observatory and the Meteorological Office consisted of registering continuous records of meteorological, magnetic and seismograph instruments, taking numerous eye-observations of meteorological and magnetical elements, reduction and tabulation of the data so obtained, the publication of a Daily Weather Report (for 7 months—May to November—under the revised arrangement), taking star or sun observations for time determination, receiving, rating and issuing a large number of chronometers belonging to the Royal Indian Marine and Royal Navy, directing the local time-ball service at the harbour and collecting extracts from weather logs of ships. All these were satisfactorily carried out during the year ; about 81 chronometers were rated and issued and 953 weather logs from ships were collected. The preparation of hourly normals of meteorological elements based on data for 1846 to 1920 was completed during the year and sent for publication.

30. *Calcutta, Alipore.*—In addition to the issue of the Daily Weather Report for northeast India, the Calcutta Office and Observatory have the important duties of supplying all Indian observatories with instruments and stores, keeping a stock of the tested instruments, checking and computing a portion of the data accumulated from observatories, supplying mean local time to the Port of Calcutta and by wireless to shipping at sea, distributing the departmental publications through the agency of the Central Publication Branch and attending to some of the routine correspondence of the department as a whole. The Calcutta Daily Weather Report was published throughout the year in its pre-retrenchment form. The arrangement made last year, in connection with cyclone warning for the Bay, of providing Calcutta with duplicates of telegrams of all special observations from coast stations continued throughout the year. Wireless time-signals were sent out from Calcutta at 14 hrs. and 22 hrs. (Indian Standard Time), and the electric diffuser was regularly used for this transmission. The Meteorologist, as a member of the North Bengal Flood Enquiry Committee, added another part to the report under " North Bengal Floods ", which he submitted last year to the Government of Bengal. This part contains a general discussion of variabilities of rainfall and inter-class correlations for different periods and of fluctuations of rainfall in north Bengal.

31. *Madras Observatory.*—The most important routine work, the supply of time to the local shipping, and throughout the Indian telegraph system to the whole country generally, was carried out satisfactorily. The yearly period of publication of the Madras Daily Weather Report, which was shortened by three months in the year as a measure of retrenchment, by the omission of January, February and March, was revised on 1st January 1926 and the

Report will in future continue to be published throughout the year, until the next retrenchment, or perhaps some adequate cause, dictates a change.

32. *Kodaikanal.*—The collection and measurement of spectroheliograms from foreign observatories have been continued as a part of the programme of the International Astronomical Union. At the instance of Lord Rayleigh, the observatory is taking part in his scheme of observations for determining the luminosity of the night sky. A report on the astronomical work of the observatory during the calendar year 1925 was published in March 1926. Orders were received during the year from the Government of India retaining the Assistant Director's quarters for the use of the observatory as its library and store house.

33. *Other Observatories.*—A number of observatories keep continuous instrumental records of certain meteorological elements ; 6 stations record wind by Beckley anemographs, 4 by Dines' anemograph, 6 record hours of sunshine, 15 deal with air pressure and 7 with air temperature.

Of the purely meteorological observatories under the department's care 44 were non-departmental and 216 were maintained by the Government of India ; these include stations as far afield as Tehran, Kashgar, Aden and Seychelles. According to the classification given in the report for 1918-19, the departmental observatories consisted this year of 6 of the first class, 178 of the third class, 7 of the fourth class and 25 of the fifth class. The maintenance of these observatories, the supply to them of tested instruments, and the careful scrutiny of their observations naturally entail much work of a routine character at headquarters. The correctness of observations depends upon the continuance of good exposure and good condition of instruments at observatories, and upon the accuracy of reading by observers. The former point can only be ensured by visits of inspection by trained officers. The latter point can to some extent be estimated at headquarters from the number of mistakes detected in the data for the Indian Daily Weather Report. The stations of great reliability, in which no mistake or at most one has been detected, numbered 30, and the number at which more than 50 mistakes were made was 2. The average number of mistakes during the year at the remaining stations was 10.

34. *Inspection of Observatories.*—One of the essentials for continued accuracy of meteorological observations is frequent inspection of observatories. This feature had been neglected for many years owing either to want of funds or to inadequate staff ; but a marked improvement took place after 1922-23 with more liberal inspection in the following year, chiefly of those stations on the coast lines between Rangoon and Karachi. During 1924-25, eighty-eight observatories and during 1925-26, 63 were inspected by Meteorologists and others. The Director-General visited the principal observatories at Bombay, Agra, Alipore (Calcutta), Kodaikanal, Madras and Bangalore.

Inspection of Upper Air stations at intervals is very necessary, but only three such stations, Diamond Harbour, Karachi and Poona were visited during the year, as staff for the purpose was scanty.

Marine Meteorology.

35. Wireless weather messages from ships at sea, and extracts from weather logs of ships calling at the principal ports on the Indian seaboard, are the chief sources of marine data collected by the department.

The object of the system of radio-messages from ships is mainly to supplement the coast observations in cyclone-warning work. In the absence of observations from sea areas it is not always easy to draw correct conclusions about the position, movement and intensity of storms ; this is the case particularly with disturbances in the Arabian Sea for which inferences have had in the past to be drawn from very insufficient observations from the west coast

line of India. The system of wireless weather messages which was started in 1914, but which was necessarily suspended during the war, was resumed in 1921. It showed improvement over preceding years during the year under report ; thus the number of ships' messages from the Bay and the Arabian Sea totalled 3,689, in comparison with 3,633 in the previous year and 956 in 1921-22. The department gratefully acknowledges the assistance given by commanders of ships who took part in this service, and would especially mention the following steamers from whom more than 40 weather messages were received during the year :—

S.S. "Arankola" .. 56	S.S. "Ekma" .. 67	S.S. "Manipur" .. 47
„ "Aronda" .. 64	„ "Erinpura" .. 84	„ "Narkunda" .. 55
„ "Aungban" .. 104	„ "Havildar" .. 51	„ "Nurjahan" .. 51
„ "Badarpur" .. 119	„ "Jaladuta" .. 71	„ "Ormara" .. 54
„ "Chanta'a" .. 45	„ "Karagola" .. 47	„ "Shah'aban" .. 48
„ "Chindwara" .. 64	„ "Koh'nur" .. 54	„ "Shahzada" .. 68
„ "Domala" .. 49	„ "Maharaja" .. 107	„ "Takhwa" .. 112
„ "Edavana" .. 55		

This is a gratifying increase, but even yet the department's warning officers frequently lack, at critical times, ships' observations from the vicinity of a storm at sea and find themselves compelled to draw their inferences and base their broadcast messages on coast observations alone. It is hoped that as more ships come to co-operate with the warning service the number of such occasions will steadily diminish. It would be most helpful if co-operating captains would induce others to take a share in this service of information from sea. A message which may appear colourless to a ship captain when despatching it is frequently of great use.

The Madras-Rangoon mail boats were provided with two good barographs, in accordance with the policy of issuing instruments on loan to ships' commanders. The results have been satisfactory and this policy, when extended, will certainly be fruitful in increasing a knowledge of the meteorology of the Indian Seas ; but lack of sufficient gazetted staff prevents at present an extension in this direction.

Apart from ships' wireless messages, an important source of data is the log extracts taken by clerks in Calcutta and Bombay. In this connection the new opening which was created in Rangoon earlier, through the helpfulness of the Port authorities, allowing the observers of the Time-Ball and Tidal observatory of the Port Commissioners to collect ships' data, continued to give valuable service. Occasionally, in special cases, logs of steamers with experience of disturbed weather are collected at Madras ; and the Colombo Port authorities also help similarly whenever requested. A total of over 2,000 logs recorded at the end of the year.

The data thus obtained are entered on charts of disturbances in the Bay of Bengal and the Arabian Sea, and kept for reference in the storm-warning work of the department, and in drawing up an account of the storms of the year for publication in the India Weather Review (Annual Summary).

Rainfall Registration.

36. The registration of rainfall in India has always been carried out under the control of provincial authorities. In 1889 a uniform system was introduced by the Government of India, and the Director-General of Observatories was made consulting officer in connection with this work. His advice is sought

regarding the starting of new raingauge stations, and he receives annual reports upon the efficiency of the work from the local controlling officers, who are in most of the provinces the Directors of Agriculture or of Land Records.

The following is a statement giving number of raingauge stations in India totalling 3,313 as they stood in January 1926 :—

Province.	No. of stations.	Province.	No. of stations.
Burma	243	Rajputana	338
Assam	126	Bombay	274
Bengal	253	Central India	151
Bihar and Orissa	317	Central Provinces and Berar (including Irrigation Department.)	168
United Provinces	284	Hyd rabad	18
Punjab	191	Mysore (including Taluks) ..	227
Kashmir	41	Coorg	10
North-West Frontier Province ..	34	Madras (including Feudatory States).	494
Baluchistan	80		
Sind	64		

In 1920 the necessity of frequent inspections of raingauges was brought to the notice of the officers in charge of rainfall registration, and subsequent reports have shown a decided improvement in this subject.

The following notes are based on the reports for 1925-26 of these officers :—

Burma.—The total number of stations during the year under report was 243 against 241 last year ; of these 18 are meteorological observatories, 30 are in charge of P. W. D. ; 2 under the control of the Director of Agriculture, and the rest under the supervision of Civil Officers. 218 raingauges were inspected, against 217 in the previous year. The inspections were satisfactory. The main defect was, as usual, near ness to buildings and trees. Steps were taken to remove these defects and to improve the number and quality of the instruments in use.

Assam.—There were 126 stations at the end of the year. One new station was opened at Sylhet. The number of raingauges inspected was 101 against 114 last year. Of these there are 8 raingauges belonging to the meteorological department. The districts are generally well equipped with raingauges and their accessories.

Bengal.—The number of raingauges at the end of the year was 253. Two stations, one Henria (Midnapore) and the other at Jalapahar (Darjiling), were abolished, while four new stations were opened, two in Murshidabad, one in Rajshahi and one in Bogra. The number of stations inspected was 229 against 197 in the preceding year. The condition of the raingauges in the province is reported to have been good on the whole, defects pointed out by the inspecting officer having been promptly remedied.

Bihar and Orissa.—There were 317 raingauges (including 30 in the Feudatory States of Orissa and Chota Nagpur). A new station was started at Gudri in the district of Singhbhum. The number of stations inspected was 270 against 255 of the last year. The condition of raingauges was generally well maintained.

United Provinces.—There were 284 rain reporting stations including 16 meteorological observatories, as against 286 last year. Of the 268 stations under District and Canal Officers 88 per cent. were inspected during the year as compared with 79 per cent. in the previous year. Two new stations were opened (Dasna in Meerut and Buland

Shahr in Buland Shahr). Four stations were abolished, namely (1) Mohaban in District Muttra, (2) Mirganj in District Bareilly, (3) Ghazipur in District Fatehpur and (4) Bara in District Allahabad.

Punjab.—There has been no change in the number of raingauges during the year. 119 stations were inspected during the year by Civil Officers.

North-West Frontier Province.—There were 34 raingauges : of these 31 were inspected and reported to be in good order, except the one at Chitral, where some repair to the masonry pillar was needed.

Baluchistan.—There were 80 raingauge stations and 10 meteorological observatories including a new observatory opened during the year at Sibi. 23 raingauges in charge of the Civil Department were inspected by District Officers as against 18 in the preceding year. The raingauges at Sunri railway station and at Chagai were removed, as the railway station at the former place was closed and the retention of the gauge at the latter was considered unnecessary. A new station was established at Sorab in the Kalat State on the 8th June, 1925 and the recording of rainfall was commenced at Yak Mach and Nok Kundi railway stations in April 1925 and January 1926 respectively.

Bombay.—There were 338 raingauge stations including those in Sind and the Native States : out of these 224 were inspected. In the Presidency proper there were 277 stations, of which 207 were inspected as against 242 in the previous year ; while out of 61 raingauges in the Indian States 17 were inspected as against 40 in the last year. The report of the Director of Agriculture, Bombay Presidency, Poona shows :—

> " The progress made in the direction of raingauge inspection in the last year has not been maintained during this year but inspection work has, nevertheless, been generally satisfactory in the Presidency proper and in Sind. In the case of native states, however, it must be admitted that the inspection work has not been very satisfactory. The attention of the officers concerned in the native states, as well as those in the British Districts, is being invited to the importance of this piece of work and they are being requested to give more attention to the work of raingauge inspection in future."

Rajputana.—Reports on the rainfall registration were received from all the states. In all there were 338 raingauge stations, out of which 301 were inspected as against 311 last year.

Central India.—Reports on the rainfall registration were received from almost all the states in the Central India Agency with the exception of Indore. 151 raingauges were inspected against 153 of the previous year. The raingauges were reported to be in good and satisfactory condition.

Jammu and Kashmir State.—There were 41 stations altogether, of which 8 are meteorological observatories. The number of raingauge stations inspected during the year was 18 against 21 last year.

Central Provinces.—The number of raingauges in the Central Provinces and Berar remained unchanged at 125 and 43 respectively. This figure excludes the raingauges maintained by the Irrigation Department. The opening of a new raingauge at Dhamangaon in Berar has been sanctioned, but the work has not yet been done. The number of inspections of raingauge stations was slightly reduced in the Central Provinces and slightly increased in Berar. It was 307 against 309 in Central Provinces and 122 against 115 in Berar the previous year. Of the 168 raingauges, 13 are maintained by the meteorological department and the remaining 155 are managed by medical, police and agricultural departments and by Feudatory States.

Hyderabad.—There were 18 raingauges in direct charge of the P. W. D. under the supervision of observers who are the officials of the Public Works Department. All these gauges were inspected by the Divisional Officers, and were reported to be in good working order.

Mysore.—There were 227 raingauge stations as against 226 in the previous year. Of these, 77 are at district and taluk headquarters and the rest in villages. 214 stations were inspected in 1925-26 as compared with 203 stations in the previous year.

Coorg.—The number of raingauges was 10. Seven stations were inspected during the year and found to be in good order.

Madras.—There were 504 raingauge stations (excluding meteorological observatories) in the Madras Presidency and feudatory states, against 492 last year. The number of stations inspected during the year was 469. The condition of the raingauges was generally good.

Baroda.—No report has been received; and it is understood that none can be sent for this season's work.

A general review of the report reveals the satisfactory fact that in almost all the divisions a high proportion of the raingauges was inspected.

37. *Heavy Rainfall Reports.*—Heavy rainfall is occasionally so very local that small areas can have as much as 10″ of rain without the Daily Weather Report conveying the least suggestion of it. With a view to have such useful data promptly available for the Daily Weather Report it was arranged in 1921, with the approval of the Government of India, that reports of 5 inches or more of rainfall should be telegraphed to Simla from raingauge stations at district headquarters throughout the country. The number of such telegrams received during 1925-26 was 134 as compared with 180 in the previous year.

Snowfall Registration in the Mountain Districts to the North and West of India.

38. Information as to the amount, distribution and time of occurrence of snowfall in the Himalayan and Afghan mountain areas was on the whole tolerably complete, and the thanks of the department are due to the various officers who collected and forwarded it.

Seismological Observations.

39. Seismological observations were recorded throughout the year by two Omori-Ewing seismographs at Simla, two at Calcutta and one at Bombay, and by a Milne seismograph at Kodaikanal. At Bombay (Colaba) the new Milne-Shaw machine has worked excellently since its installation in 1922-23. All the seismic data collected at these places are sent to the Seismological Committee of the British Association.

Time Signals.

40. The observatories at Madras, Calcutta and Bombay determine time from star and sun observations, and communicate it to the local ports by time-ball signals. The distribution of time over the country generally is made from the Madras Observatory by a signal transmitted daily at 16 hrs. (Indian Standard Time) over the Indian telegraph system ; considerable errors are inevitably introduced into the signal at stations where retransmission is affected by hand. A wireless time signal for the use of ships was broadcasted automatically twice daily from the Alipore Observatory at 2 P.M. and 10 P.M. I. S. T. through the Calcutta radio station.

The wireless receiver put up at the Bombay Observatory was used regularly from November 1924 for a comparison of the local time determination with the time signals transmitted from Calcutta, Eiffel Tower and Nauen.

The time work was satisfactory throughout the year.

Publications and Library.

41. The routine publications of the Department are shown at length in the Administration Report for 1922-23.

The Daily Weather Telegram was despatched to subscribers daily about noon, and the weekly rainfall summary was supplied to the *Gazette of India.* The Weekly Weather Report, containing matter similar to the Weekly Summary published in the *Gazette of India,* was published during the monsoon period, and supplied to about 42 subscribers and also to the Press.

The quinquennial volume for 1916-20 of the Bombay observatory was published in January. The printing of the first Bombay Annual Volume, that of 1921, was nearing completion at the end of the year and is expected to come out shortly. The manuscript of the Annual Volume, 1922, was sent to the press and considerable progress has been made in its printing.

The number of institutions, etc., on the distribution lists of the department was 335 at the end of the year.

The following publications were issued during the year :—

1. Indian Meteorological Memoirs, Volume XXIV, Part XI—" Rainfall types in India in the cold weather, period, December 1 to March 15 ", by Sir Gilbert Walker and J. C. Kamesvara Rav.

2. " Storm tracks in the Bay of Bengal, 1891-1923 ", by C. W. B. Normand.

A publication entitled " Storm Tracks in the Arabian Sea " was sent to the press and will be out shortly.

Books, periodicals and pamphlets either purchased or received as presentation copies in the department's libraries at Simla and Calcutta during the year numbered 1019. In regard to classification of current literature 358 current books and pamphlets were catalogued and indexed.

Concluding Remarks.

42. The Meteorological Department owes a large part of its usefulness to the sympathetic assistance it receives from other departments. Civil Surgeons and other officers of Government departments, as honorary superintendents of observatories and in other capacities, help in the meteorological work ; the Posts and Telegraphs Department assists in the rapid transmission of meteorological information ; at the same time they allow their employees to act as observers. The Indo-European Telegraph Department, also, by giving free transit to the daily messages from the Persian observatories, places a large amount of most useful information at the disposal of the Meteorological Department. Weekly telegrams are received from April to September from the Director, Royal Alfred Observatory, Mauritius, and from April to October from the departmental observatories at Zanzibar and Seychelles. These telegrams give valuable information of the weather conditions in the Indian Ocean, and the department is indebted to the officers indicated for the punctual transmission of the information. Thanks are further due to the Director of the Royal Alfred Observatory for his courtesy in placing the meteorological data of that observatory at our disposal.

The department is greatly indebted for important information on meteorological conditions prevailing before and during the southwest monsoon to the Controller, Physical Department, Cairo ; the Directors of the observatories at Buenos Ayres, Santiago and Batavia ; the Astronomer Royal, Cape Town ; Director, L'Observatoire Physique Central, Leningrad ; the Secretary, Friends' Industrial Mission, Banani Pemba, Zanzibar ; the Principal Medical Officer, Tanganyika Territory, Dar-es-Salaam ; the Commonwealth Meteorologist,

Melbourne ; Director of Agriculture, Salisbury, Rhodesia ; Chief of the Weather Bureau, Washington ; and to the various officers around the Indian frontiers who have collected and supplied valuable snowfall information.

The thanks of the Department are due to the Superintendent of Colombo Observatory, for the very useful help he has rendered from time to time in connection with storm warning work. The department is also grateful to the Director, Koninklijk Magnetisch en Meteorologisch Observatorium, Batavia, Java who has arranged for taking and telegraphing to Simla daily observations from Sabang in Sumatra during the cyclone months April, May and October to December.

J. H. FIELD,

Director-General of Observatories.

SIMLA ;

The 13th September 1926.

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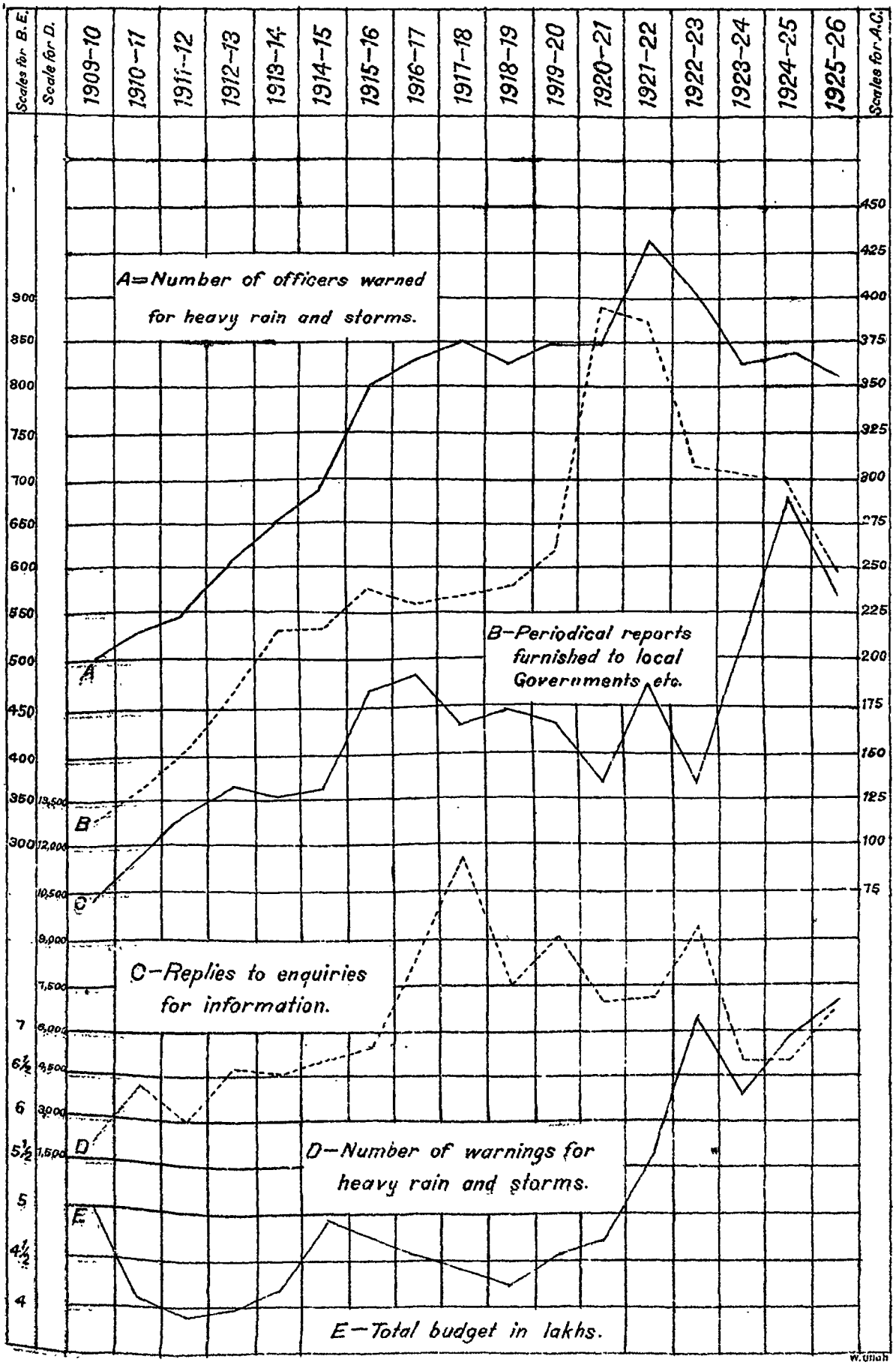
GROWTH IN ACTIVITY AND COST



Report on the Administration of the Meteorological Department of the Government of India in 1926-27.

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Chief features of the year.

The year under review was marked by many important developments. The storm warning duties for the Bay of Bengal were transferred from Simla to Calcutta, a change that was welcomed by the shipping community. A start was made towards the transfer of departmental headquarters from Simla to Poona, where building operations were begun under the supervision of private architects on 10 acres of land adjoining Ganeshkhind Road ; it is expected that the move will be effected in 1928 by transfer of the Simla staff to Poona in suitable batches. A new meteorological office was established at Karachi, its initial function being to issue weather reports and forecasts for the flying-sector, Karachi to Chahbar ; this is the extent of India's meteorological contribution in aid of the Cairo-Karachi aeroplane service. In connection with the larger Imperial Airship Scheme due to start in 1928 or 1929, India was asked by His Majesty's Government in England to undertake responsibility for supplying meteorological information for the section extending from Basra to Karachi. Should a regular service be established, the necessary organisation for such co-operation will be extensive and a provisional scheme detailing the probable ultimate requirements was submitted to Government for consideration. A more limited scheme for immediate meteorological research in the Persian Gulf and at Karachi was recommended to Government for early sanction ; one cannot afford to neglect the need for suitable preparation, because a few disasters in the earlier days of air transport following too scanty a meteorological preparation and provision might retard for a generation the progress of Empire Flying.

2. On the occasion of the visit to India of the Royal Agricultural Commission, a call was made from the department for a considered statement of the possible co-operation between meteorology and agriculture with a view to agricultural improvement. This statement was submitted in July 1926. Moreover a personal interrogatory, at a meeting of the Commission in Simla in October, was welcomed by Mr. Field as a means of explaining his recommendations. The main points dealt with related first to work on correlation between the available records in meteorology, agriculture, fluctuations in extent of land cultivation and in prices of crops ; and secondly to experimental physical work on the conditions affecting growth of crops and forests. Mr. Field advocated

an immediate start in research in agricultural meteorology, but no progress has since been made as the Commission preferred not to make any interim recommendations on the subject.

3. With regard to scientific progress special attention may be directed towards advances in upper air work. The Agra observatory and its sub-stations continued to observe and record wind velocities in the upper layer of the atmosphere and these are of great assistance in connection with weather forecasting and storm-warning. Agra has also collected valuable observations of air pressures and temperatures aloft by means of light instruments attached to free balloons, of which 60 per cent. have been recovered ; 13 of these penetrated the stratosphere and furnished information about that strange region where air temperature ceases to fall with height and temperature inversion begins. The base of this region, the stratosphere, is about 12 miles above sea-level in the Indian latitudes and this is the height at which the lowest air temperatures are found. Above the base of the stratosphere, temperature rises with increasing height ; and the records led to the tentative conclusion that this inversion may be stronger during the monsoon than in the hot weather months. The lowest temperature recorded was —83°C. at a height of 17.7 Km. on the 10th October 1926 : higher up the air temperature rose again to —65°C. at 19.7 Km. the maximum height reached on that date. Another special feature of the year has been the starting of weather observations by aeroplanes in India. Numerous records of the distribution of upper air temperature, pressure and humidity have been obtained in European countries by means of aeroplane ascents, but hitherto corresponding data for the Indian area have not been available. Thanks to the valued co-operation of the Royal Air Force Headquarters, service machines have furnished many records of air temperatures aloft at Peshawar, Risalpur and Kohat ; and it may be possible in the near future to extend the observations to other centres also. The need for still further extensions of upper air work has long been felt, and Government was asked, and agreed to provide funds in 1927-28 for the starting of 15 additional pilot balloon stations, 13 of which will be in the Indian area and 2 outside India, at Aden and Seychelles. The department regards it of importance that the whole set of 15 stations should begin work as nearly simultaneously as is practicable, for the scheme is a self-contained whole, and any policy of spreading this extension over 2 or more years would be wasteful of time and money, since the " yield " of a partial scheme would be much less than the proportion of cost involved in it. For the first year a reduced initial grant has been asked for, because the starting of the stations will take time, and expenditure will not therefore be at once on the full annual scale of approximately one lakh.

4. Under other heads of scientific progress the department continues its seismographic records at various centres, its magnetic work at Alibag and Bombay, and its solar physics work at the Kodaikanal Observatory, where interesting records of the great sunspot activity of the year were obtained. A remarkable feature of the solar activity was an eruptive prominence on the 10th December which was observed to ascend rapidly to a height of over 400,000 miles.

An experimental investigation was made at Simla on the sky illumination and polarisation at sunrise and sunset, and a paper on this subject will shortly be published as a departmental memoir. Another investigation dealt with the degree of correspondence between direction of barometric gradient and direction of wind at various heights above the surface at Agra and Bangalore.

5. The department has maintained its utilitarian services of daily time signals and of telegraphic warnings for heavy rains on land and for storms at sea and has continued publication of various periodicals such as daily, weekly and monthly weather reports, which provide matter of immediate interest

to agriculturists and to many commercial and industrial concerns. Warnings for the Arabian Sea were issued on 39 occasions, 4 for moderate to severe storms, and the others mainly for depressions or for squally weather due to advances of monsoon and to winter disturbances passing eastwards across northern India. For the Bay of Bengal warnings were issued for 25 periods of disturbed weather of which 3 developed into moderately severe storms and one into a cyclone. Numerous weather reports were supplied in connection with aeroplane flights, notable amongst these being the flights of His Excellency the Viceroy over the frontier, of Sir Samuel Hoare over Baluchistan and north-west India and of Sir Alan Cobham *en route* to and from Australia.

6. The increased activities and changes in the department have, as was anticipated, led to a somewhat difficult position at headquarters. It is to be regretted that, at this critical juncture, circumstances forced the originator of these changes, Mr. J. H. Field, who so ably directed the department for the last 3 years, to take leave preparatory to retirement. Moreover, with the transfer or 2 experienced officers, one to Calcutta and another to Karachi, the Officiating Director-General at Simla is left with only one officer of experience, to carry on with the help of the newly recruited officers fresh to their duties, the normal work of the department with the additional call for attention to the coming transfer of the headquarters to Poona. It is unlikely that with the increased scale of work matters will again become normal for some years yet, since the dispersal of practised officers on decentralised duties can only cease to be felt at headquarters when the new officers have in course of time acquired the necessary minimum of experience. In this connection it should, however, be noted with appreciation that Government have sanctioned an increase in the gazetted staff, a step which, it is hoped, will in due course, prevent undue dislocation of work at headquarters, should important changes on a large scale again occur.

Marine Meteorology and Storm Warnings.

7. *Marine Meteorology.*—Wireless weather messages from ships at sea, and extracts from weather logs of ships calling at the principal ports on the Indian sea board, are the chief sources of marine data collected by the department.

The object of the system of radio-messages from ships is mainly to supplement the coast observations in cyclone-warning work. In the absence of observations from sea areas it is not always easy to draw correct conclusions regarding the position, movement and intensity of storms ; this is the case particularly with disturbances in the Arabian Sea for which inferences have had in the past to be drawn from very insufficient observations from the west coast line of India. During the year under report the co-operation of ships in the matter of wireless weather messages showed a further improvement over preceding years. Thus the number of ships' messages from the Bay and the Arabian Sea totalled 4,282 as against 3,689 in the previous year and 956 in 1921-22. The department gratefully acknowledges the assistance given by commanders of ships who took part in this service, and would especially mention the following steamers which sent more than 40 weather messages each during the year :—

S.S. "Arankola"	55	S.S. "Erinpura"	83	S.S. "Maroada"	44
" "Aronda"	58	" "Ethiopia"	82	" "Nurjehan"	43
" "Aungban"	64	" "Fooksang"	45	" "Ormara"	58
" "Beme"	65	" "Havildar"	45	" "Pundit"	62
" "Barpeta"	83	" "Herefordshire"	44	" "Razmak"	52
" "Bahadur"	69	" "Homefield"	47	" "Shahjehan"	49
" "Badarpur"	100	" "Jalapalaka"	50	" "Shahzada"	93
" "Cocanada"	65	" "Kohinur"	51	" "Tilawa"	90
R.I.M.S. "Clive"	55	" "Laisang"	40	" "Varsova"	67
S.S. "Ekma"	68	" "Maharaja"	47	" "Warialda"	48
" "Elephanta"	95	" "Mundra"	44		

This is a gratifying increase, but even yet the department's warning officers sometimes feel the want, at critical times, of ships' observations from the vicinity of a storm at sea and find themselves compelled to draw their inferences and base their broadcast messages on coast observations alone. This is undoubtedly partly due to interruption of wireless transmission by bad atmospheries, and may also, it is hoped, be partly due to the success of the broadcast warnings in helping ships to avoid storms. Nevertheless it is felt that further co-operation is possible, and it would be most helpful if co-operating captains would induce others to take a share in this service of information from the sea. It is noteworthy that a message which may appear colourless by itself is frequently of great use when considered along with other observations plotted on a chart.

8. The policy of lending meteorological instruments to captains for shipboard use is being slowly introduced. Five captains have been supplied with barometers and this policy will be extended considerably when the additional gazetted staff, now sanctioned, have been trained. It may be noted that recipients of these instruments regularly send weather logs collected in Indian waters.

9. Shipping firms also co-operate with this department in helping to augment weather information from the high seas. Special mention may be made in this connection of the willing help rendered from time to time by Captain E. Trott, Marine Superintendent of the Asiatic Steam Navigation Company, and Captain H. J. Rouse, Marine Superintendent of the British India Steam Navigation Company.

10. Apart from ships' wireless messages, an important source of data is the log extracts collected in Calcutta and Bombay. The observers of the Time-Ball and Tidal observatory of the Rangoon Port Commissioners also have continued their useful collection of ships' data. Occasionally, in special cases, logs of steamers with experience of disturbed weather are collected at Madras ; and the Colombo Port authorities also help similarly whenever requested. A total of over 2,000 logs was recorded at the end of the year.

11. The data thus obtained are entered on charts of disturbances in the Bay of Bengal and the Arabian Sea, and kept for reference in the storm-warning work of the department, and in drawing up an account of the storms of the year for publication in the India Weather Review (Annual Summary).

12. *The system of storm warning for ports and shipping.*—The warning of ports and shipping in the Arabian Sea and the Bay of Bengal against the approach of cyclonic storms, or of bad weather, was done from Simla during the first ten days of April, 1926. From the 11th onwards warnings for the Arabian Sea continued to be issued from Simla but similar duties for the Bay were then transferred from Simla to Calcutta, a change which has been received with appreciation by the shipping community. An account of the warning system as it stood in 1918, will be found in the " Code of Storm Warning Signals for use at Indian Ports ". At present the storm warning list consists of 33 ports on the west coast and 28 ports on the Bay of Bengal. In addition to these regular ports there are 8 river ports, 14 River Police Stations and 41 District Police Stations which have to be warned in connection with disturbed weather at the head of the Bay of Bengal. Of the Bay ports 12 are provided with additional information regarding the particular areas in which weather is disturbed by a special system of ' locality signals '. Shipping at sea is also supplied with the latest weather information by means of wireless bulletins, broadcasted twice daily or more frequently when necessary. The radio stations at Bombay, Karachi and Aden serve the Arabian Sea area, those at Calcutta,

Rangoon and Madras the Bay of Bengal area, and the wireless station at Matara, Ceylon serves both the areas.

The number of warning messages for ports and the two sea areas issued by the department during the year was 8,425. These messages include all radio weather broadcasts from the 7 wireless stations and all warning telegrams by land-line during storms or periods of disturbed weather to the Bay of Bengal and the Arabian Sea ports.

13. *Warnings to ports and shipping in the Bay of Bengal.*—During the year warnings were issued for 25 periods of disturbed weather. The disturbances developed into moderately severe storms on 3 occasions and once into a cyclone. This cyclone had its origin in the southwest of the Bay of Bengal during a temporary advance of the monsoon in the middle of May. On the morning of the 18th a depression had formed in the neighbourhood of Ceylon. It developed into a storm during the next day and its centre was located near Lat. 9° 30′ N., Long 84° 30′ E. on the morning of the 19th. While moving in a northnortheasterly direction the storm rapidly developed in extent and severity and crossed the coast between Akyab and Cox's Bazar before midnight on the 22nd. It was a severe cyclone on this day, with hurricane winds near its centre as well as to a considerable distance in its southern quadrant. The S. S. " Yuensang " which passed within about fifty miles of the centre on the 22nd reported winds of hurricane force from 2 hours to noon, and the barometer on board fell to 28.96 or about 0.7″ below normal. After crossing the coast, the storm weakened into a depression and continued to move northwards, disappearing in Burma by the morning of the 24th. A tidal wave in the Naaf river is reported to have inundated a large part of the country in the Maungdaw and Buthidaung townships of the Akyab district, and washed away many villages, causing considerable loss of life and heavy damage to property.

Of the moderately severe storms, the one during the Christmas week, 1926 may be described in some detail. The storm began with unsettled conditions in the Andaman Sea which after passing out into the Bay developed by the morning of the 24th December into a depression with centre near Lat. 10° N. Long. 87° E. During the day the depression intensified into a storm and moving in some northnortheasterly direction reached the region near Lat. 20° 30′ N. and Long. 89° 30′ E. by the morning of the 27th. The storm weakened rapidly as it approached the coast, passed inland near the mouths of the Meghna on the night of the 27th and disappeared the next day over south Assam. The storm was characterised by high winds at some distance away from the centre with relatively light winds near the core, and thus resembled the monsoon storms in the north of the Bay of Bengal.

Reports on the working of the warning system were received every month by the Meteorologist, Calcutta, from officers on the warning lists. Most of the officers gave no remarks or stated that the warnings were satisfactory. The only noteworthy criticism was that from the Port Officer, Chittagong, who complained that during the storm of the 22nd to 26th November, 1926 the warning for the near approach of the storm to Chittagong reached him later than it did the Collector of the district. The facts of the case are that in the early morning of the 25th November a message was sent to the Port Officer, followed by another message after examination of the 7 hours observations, when he was asked to hoist the local warning signal number 4. As the local warning signal was already hoisted and as there was no immediate danger to the port of Chittagong, the Meteorologist did not consider it necessary to send a message again after examination of the 8 hours chart but awaited receipt of the next set of observations at 11 hours before taking further action regarding the Port. Meanwhile however he had to consider action under the standing arrangement

by which district and police officers in Bengal are to be warned of the approach of cyclones. The first intimation to this effect was sent to the Collector and Police Officers of the Chittagong district after examination of the 8 hours chart, *i.e.*, before final action was taken with regard to Chittagong Port.

The following appreciative remarks in a letter of the 6th June, 1926, from the Commander of S. S. " Warialda " are of interest :—

> " I feel that it is incumbent on me to express my thanks for your excellent wireless warning messages regarding the severe storm which occurred in the Bay at the end of last month (May).....Your messages enabled me in a heavily laden ship in a critical position with reference to the storm successfully to evade it."

In connection with the same storm the Officer-in-Charge of Cox's Bazar port wrote :—

> " The warning issued regarding the storm of the 22nd May, 1926, was quite timely and was very useful as without it there might have been considerable loss of life and property."

The Port Officer, Akyab, in his letter dated 3rd June, 1926, stated :—

> " If timely warnings had not been issued....., there would have been more damage caused to the launches, cargo-boats and country-boats in the harbour."

14. *Warnings to ports and shipping in the Arabian Sea.*—The west coast ports are warned not only for storms but also for squally weather, especially at the beginning of the monsoon. During the year warnings were issued for 39 periods of disturbed weather ; on 20 occasions the warnings were for squally weather or strong winds connected with the monsoon, on 15 occasions for rough weather in the extreme north or northeast Arabian Sea caused by the eastward passage of western disturbances through Persia and on the remaining 4 occasions for storms of moderate to severe intensity.

The first storm began as a depression in the northwest of the Bay of Bengal on the 6th August. The depression was at first shallow, but moving westwards through Orissa to the Central Provinces and Gujarat passed into the northeast Arabian Sea, and developed into a storm. The second had its origin in a depression over southeast Rajputana. Moving westsouthwestwards, it reached Gujarat on the morning of the 3rd September and developed into a storm, and passed into the northeast corner of the Arabian Sea between Kathiawar and Cutch by the morning of the 5th. The storm gave 14″ of rain at Karachi from the afternoon of the 4th to the morning of the 6th an amount which is about twice the annual normal and caused extensive damage to property in the city. The third storm of the year also occurred in September. A depression appeared off the north Konkan on the morning of the 15th. It intensified into a storm off Veraval on the next day and caused heavy falls of rain in Gujarat.

The last storm originated as a depression in the Gulf of Manaar on the 6th November 1926. It moved slowly into the Arabian Sea and was found to lie near Minicoy on the morning of the 8th November. Owing to the complete absence of reports from ships its further development could not be traced till the morning of the 13th when S. S. " Port Darwin " reported gales and squally weather from Lat. 8° N. Long. 56° E. With the help of the data received from this ship and others, which responded to requests for special observations broadcasted on behalf of this department, it was presumed that the depression had already developed into a storm of small diameter off the Somaliland coast. Moving further in a northwesterly direction the storm, which was remarkable for giving very rough weather off the coast near Italian

Photos I. Sequeira, Camp, Karachi.

KARACHI FLOODS, 5TH SEPTEMBER 1926. SCENE AT MCLEOD ROAD, KARACHI.

Photo.-engraved & printed at the Offices of the Survey of India, Calcutta, 1927.

Somaliland and in the Gulf of Aden, probably dissipated near Cape Guardafui by the 17th.

For the Arabian Sea area reports on the working of this marine warning system were received from 18 officers on the warning lists. Of these 15 considered the warnings to be satisfactory or gave no remarks ; and the remaining 3 offered minor criticisms which received consideration.

In connection with the storm which affected Karáchi on the 5th September, the following statement appeared in the " Statesman ", Calcutta, of the 8th September, 1926 :—

> " A warning having been given 24 hours before the approach of the cyclone, it was possible to take precautions, otherwise the resulting damage would have been much more severe."

INLAND WEATHER WARNINGS AND SPECIAL WEATHER FORECASTS.

15. Since the transfer of the storm warning work of the Bay of Bengal to Calcutta, warnings for heavy rain have been divided between Simla and Calcutta. The Meteorologist, Calcutta is responsible for areas in Burma, Assam, Bengal, Bihar and Orissa, and the adjacent parts of the United Provinces, the Central Provinces and north Madras ; all other areas are warned from Simla. The system of warnings is the outcome of attempts to meet the varied requirements of Government departments and other authorities. Generally the officers require telegrams either warning them of advancing storms likely to give heavy rain or informing them of the actual occurrence of heavy rainfall that might cause severe floods and thus injure railways or canal works. In a few cases, warnings for strong winds or weather forecasts as long in advance as possible are required.

At the end of the year the number of officers on the warning lists was 194. The recipients of warnings are mostly district officers and officers of the irrigation, railway and other departments. In addition, there were 17 officers of the Telegraph Department, who required warnings, mostly for strong winds.

In order to guard against serious loss of life and property in Bengal when a cyclone from the Bay crosses the coast, 461 officers were added in 1921 to the warning list ; of these 40 hoist the signals shown in Appendix D of the " Code of Storm Warning Signals " whenever instructed to do so.

The number of special inland forecasts and warning messages issued by the Department during the year was 2,359 and in addition 825 telegrams of actual heavy rainfall were sent by meteorological observers direct to various officers.

Reports on the working of this system were received from 139 officers. Of these, 107 stated that the warnings were satisfactory and the remaining 32 offered suggestions or minor criticisms which have received consideration.

On the whole a comparison of the inland warnings with the actual subsequent rainfall, or the tracks of storms across the country, show that most of the warnings issued proved useful to the recipients. The following remarks from the Collector of Broach in his letter, dated the 5th January, 1927, may be quoted in this connection :—

> " Owing to timely information being given no human or animal life was endangered."

The Executive Engineer, Cossye Division, Midnapur, wrote in his letter, dated the 5th January, 1927 :—

> " It is noticed this year that the warnings of the 18th July, 11th and 13th August, 1926, have been of great use since sufficient precaution could be taken to save the embankments against the action of the floods."

In a letter, dated the 28th February, 1927, the Manager and Engineer-in-Chief, Port Department, Bhavnagar State Railway, wrote :—

> " The warnings were very accurate and satisfactory, and during the cyclone season were of great value to the Railway, the Port and Master of Vessels."

In a letter, dated the 25th May, 1926, addressed to Mr. J. H. Field, Major Mason, of the Indian Survey wrote :—

> " It was most kind of you to send me the three weather reports to Srinagar, and they were most helpful. All three were absolutely correct, and the last one, on Sunday 9th, was prophetic."

16. *Weather reports to aviators.*—Since the establishment of the local forecasting centres at the R. A. F. aerodromes at Quetta and Peshawar, the R. A. F. Meteorologists have been issuing general accounts and forecasts of weather over the Delhi-Peshawar-Quetta-Karachi air routes and detailed local forecasts and warnings, each for his own immediate neighbourhood ; the Peshawar daily reports were sent to the R. A. F. at Peshawar, Kohat, Miranshah, Lahore and Ambala, and the Quetta reports to the R. A. F. at Quetta and Karachi. In addition special route forecasts were issued on more than 200 occasions by both Quetta and Peshawar. Further information about these two centres is given under " Observatories and Sub-Offices ".

Weather forecasts for aviation purposes were also given from Simla, whenever such forecasts were called for. The most important occasions, which extended over long periods and demanded forecasts at frequent intervals were in connection with the flights of Sir Alan Cobham and of Sir Samuel Hoare in India. Reports for the incoming and return flights of Sir Samuel Hoare between Persia and Karachi were issued by the newly established office at Karachi.

Headquarters Office, Simla.

17. The general administration of the department, which includes the observatories mentioned in the following paragraphs, is carried on from the headquarters office in Simla. Headquarters is also responsible for practically all climatological work in India, for the preparation of normals of rainfall, temperature, humidity, etc., for all stations, for the preparation of weekly, monthly and annual weather reports, and for the *Indian Daily Weather Report*, the preparation of which is based on some 190 coded weather telegrams which are received each morning by telegraphists in the headquarters office. Two seismographs and an upper air station are maintained at this office ; otherwise, little observational work is undertaken, a defect which, it is hoped, will be remedied after transfer of headquarters to Poona. It will be recalled that the transfer from Simla to Poona was first proposed officially by Sir Gilbert Walker in 1924, was strongly supported by Mr. Field and was sanctioned by Government early in 1926. An allotment of Rs. 2 lakhs was provided in the budget of 1926-27 for the acquisition of land, the preparation of plans and start of building. Some 10 acres of land in Bhamburda, Poona, on the Ganeshkhind Road were bought from the Bombay Government. Plans for the new office building were prepared by private architects, Messrs. Stevens and Partners of Bombay, and were sanctioned by Government at a building cost, not exceeding Rs. 5.08 lakhs, excluding architects' fees but including cost of drainage, water supply, etc. The land was taken over by the architects in December 1926 and work on the foundations was then begun.

Observatories and Sub-Offices.

18. *Agra.*—Exploration of the free atmosphere in India has been recognised as indispensable in the interest of aviation, general meteorology, and both daily

and seasonal forecasting ; and proper attention has now been directed to the starting of as many pilot balloon stations in the Indian area as possible. A scheme to this end, envisaging the start of 15 such stations received the sanction of Government towards the end of the year. A new upper air station was started at Madras in April, 1926, and regular measurement of upper winds began there from the 8th April, 1926.

The principal routine work of the year at the observatory consisted, as before, of (*a*) supply of material and equipment to the upper air stations at Quetta, Peshawar, Karachi, Lahore, Simla, Diamond Harbour, Akyab, Poona, Bangalore, Madras and Port Blair, (*b*) exercise of close supervision over work at these out-stations, (*c*) tabulation of pilot balloon results and of cloud observations, (*d*) release of instrument balloons ; 67 were sent up and 38 recovered, (*e*) repairs to barometers and anemometers, (*f*) construction of Stevenson screens, 30 of which were made and sent out to various observatories and other Government or private institutions.

Amongst special work carried out at the observatory the tests of airship fabrics under Indian climatic conditions undertaken at the request of the Air Ministry, London, are noteworthy. These had been begun in 1925-26 and were continued during the year under report. The reports for the second and third periods of exposure were sent to the Director of Airship Development, Cardington, and the Air Council expressed through the Secretary of State for India its appreciation of the tests made at Agra.

It has been decided to substitute gutta-percha balloons by rubber balloons for ordinary pilot balloon work and numerous experiments have been carried out to test the suitability of vultex material, which is much cheaper than rubber, for balloon making. Preliminary trials indicate that vultex balloons are capable of penetrating the stratosphere as often as rubber balloons.

The Agra Observatory, as usual, supplied equipment for pilot balloon work at artillery practice camps during the winter, the number of camps supplied this year being 9.

Colaba and Alibag.—The routine activities of these observatories which are administered by the Meteorologist, Bombay include supervision of the self-recording meteorological, magnetic and seismograph instruments ; the recording of numerous eye-observations and the reduction and tabulation of these data ; taking star or sun observations for time determination ; receiving, rating and issuing a large number of chronometers belonging to the Royal Indian Marine and Royal Navy ; directing the local time-ball service at the harbour and collecting extracts from weather logs of ships. The wireless receiver put up in 1924 was used regularly for a comparison of local time determination with the time signals transmitted from Calcutta, Nauen and the Eiffel Tower. Besides these the publication of the *Bombay Daily Weather Report* formed an important part of the work during the period, May to November. The work was done satisfactorily. About 44 chronometers were rated and issued, and 895 weather logs from ships were collected.

The printing of the Annual Volumes for 1921 and 1922 was completed during the year and the volumes were distributed to Indian and foreign recipients. Good progress was also made in the preparation of the 1923 volume, which will shortly be sent to the press.

At the request of Dr. A. Crichton Mitchell, a large amount of magnetic data was prepared and supplied to him for use in his research work.

Calcutta, Alipore.—In addition to the important work of storm and heavy rainfall warning the Calcutta Office and Observatory have the important duties

of publishing the *Calcutta Daily Weather Report* for northeast India, supplying all Indian observatories with instruments and stores, keeping a stock of the tested instruments, checking and computing observational data from northeast India stations as well as from a number of other Indian observatories, and supplying time-signals by time-ball to the Port of Calcutta and by wireless to shipping at sea. The other duties consist of writing the descriptions of storms and disturbances in the Bay and northeast India, collection of weather logs from steamers arriving at Calcutta and testing ships' barometers, examination of steamer logs collected in Calcutta, Rangoon and Bombay and plotting of useful observations for study of storms or disturbances, arranging for repairs of instruments such as barometers anemometers, etc., testing of instruments for the Mathematical Instrument Office and other Government offices or others on payment, supplying meteorological or allied information to institutions or individuals, distributing the departmental publications through the agency of the Central Publication Branch and attending to some of the routine correspondence of the Department as a whole. A wireless receiver installed in January 1927 was used for the comparison of foreign time-signals with the observatory clocks.

Madras.—The most important routine work, *viz.*, the supply of time by time-ball signal to local shipping, and by telegraphic signal throughout the Indian telegraph system and to the whole country generally, was carried out satisfactorily. The new Marconi wireless receiver, which was installed at the end of the previous year, was regularly used for the observation of time signals broadcasted from the Alipore Observatory. Towards the end of the year, wireless time-signals were also received from several foreign stations including Bordeaux and Nauen. These were used only for purposes of comparison, and the daily time service continued to be based as in the past, on independent determinations made at Madras. The distribution of time over the country generally is made from the Madras Observatory by a signal transmitted daily at 16 hours I. S. T. over the Indian telegraph system ; considerable errors are inevitably introduced into the signal at stations where retransmission is effected by hand. In accordance with the revised scheme of January, 1926, the *Madras Daily Weather Report* was published throughout the year.

Kodaikanal.—The collection and measurement of spectroheliograms from foreign observatories were continued during the year as a part of the programme of the International Astronomical Union. The observations of the luminosity of the night sky which were being made at the instance of Lord Rayleigh were concluded at the end of January, 1927, and at his request the instruments were returned to him.

A report on the astronomical work of the observatory during the calendar year 1926 was published in March, 1927.

Photographs obtained at Kodaikanal of an unusual disturbance on the sun are reproduced in a plate in this report. These exhibit a very unusual phenomenon, and are believed to show the finest example ever photographed. This brilliant outburst of hydrogen and calcium was due to the exceptionally active sunspot seen near the centre of the photographs and was followed by a large magnetic storm on the earth. Figure 1 illustrates the first stage which in itself is not uncommon. What is unique is to have obtained a complete series of photographs showing its development from the commencement at 8 h. 3 m. to the exceptionally bright and extensive outburst at 9 h. 4 m. when it reached its maximum. At this stage it represents the best example in the whole Kodaikanal record beginning from 1904. Thereafter its brilliance gradually declined.

FIG. 1. 8 h. 3 m.

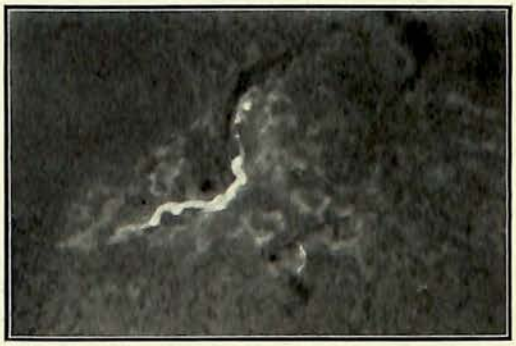

FIG. 2. 8 h. 8 m.

FIG. 3. 8 h. 36 m.

FIG. 4. 9 h. 0 m.

THIS LINE REPRESENTS 500,000 MILES.

AN UNUSUAL DISTURBANCE ON THE SUN ON FEB. 22ND 1926.

FIGS. 1, 2, 3 & 5 ARE TAKEN IN HYDROGEN LIGHT.

FIG. 4 IS TAKEN IN CALCIUM LIGHT.

(Photographed at Kodaikanal Observatory).

FIG. 5. 9 h. 4 m.

Photo.-engraved & printed at the Offices of the Survey of India, Calcutta, 1927.

Karachi.—The meteorological office opened at Karachi in December 1926 is to be primarily responsible for the development of a weather service for the Basrah-Karachi air route. In the future it will also probably, serve the meteorological needs of civil air routes connecting Karachi with other Indian centres.

Quetta and Peshawar.—The nature of the weather reports issued by the forecasting centres at the R. A. F. aerodromes at these two stations have been indicated above. The two Meteorologists-in-Charge are officers of the R. A. F. and are under their respective Wing Commanders for disciplinary purposes, but their technical work is supervised by the Director-General of Observatories.

This Department supplies instruments for the use of the R. A. F. meteorologists and meets the cost of a small clerical staff at each station. According to the original scheme R. A. F. wireless operators were to assist in the clerical and observational work but this arrangement has proved unsatisfactory and a revised scheme was submitted to Government for increased clerical staff. This Department also arranges the supply to these officers of synoptic weather information from the Punjab, Sind, the Frontier Province, Baluchistan, Persia and Arabia, and of information of upper air winds from Karachi, Lahore, Peshawar and Quetta. In addition to the regular issue of weather reports and route forecasts, the meteorologists at Quetta and Peshawar arrange for local observations by means of various meteorological instruments, some of which register continuously barometric pressure, temperature, rainfall and wind velocity. They also occasionally supply climatological information to various local officers. An important development of the work at Peshawar has been the arrangement for daily meteorological flights by aeroplane for the observation of dry bulb and wet bulb temperatures aloft, beginning from the 1st June 1926.

Other Observatories.—Of the purely meteorological observatories whose records are scrutinised by this Department 211 were maintained directly and 52 were non-departmental. Some of the departmental observatories are situated as far afield as Tehran, Kashgar, Aden and Seychelles. The departmental observatories consisted this year of 5 of the first class, 177 of the third class, 6 of the fourth class and 23 of the fifth class, according to the classification given in the report for 1918-19. The maintenance of these observatories, the supply to them of tested instruments, and the careful scrutiny of their observations naturally entail much work of a routine character at Alipore and Simla. The accuracy of observations depends upon the continuance of good exposure and good condition of instruments at the observatories, and upon the correct method of reading the instruments by observers. Good exposure of instruments can only be ensured by personal inspection by trained officers and the accuracy of observations can be estimated to a certain extent at headquarters from the number of mistakes detected in the data sent for the Indian Daily Weather Report. The stations of great reliability in which no mistake or at most one has been detected, numbered 31, and the number of stations at which more than 50 mistakes were made was 3. The average number of mistakes during the year at the remaining stations was 12.

Inspection of Observatories.—One of the essentials for continued accuracy of meteorological observations is the frequent inspection of observatories. During 1926-27, 37 observatories were inspected by Meteorologists and others. The Director-General visited the principal observatories at Bombay and Agra.

Inspection of Upper Air Stations at intervals is very necessary, but the exigencies of the service did not allow more than two such stations, Poona and Akyab, to be visited during the year.

Rainfall Registration.

19. The registration of rainfall in India has always been carried out under the control of provincial authorities. In 1889 a uniform system was introduced by the Government of India, and the Director-General of Observatories was made the consulting officer in connection with this work. His advice is sought regarding the starting of new raingauge stations, and he receives annual reports upon the efficiency of the work from the local controlling officers who are in most of the provinces the Directors of Agriculture or of Land Records.

The following is a statement of the number of raingauge stations, totalling nearly 3,100, as they stood in January 1927 :—

Province.	No. of stations.	Province.	No. of stations.
Burma	242	Rajputana	143
Assam	123	Bombay	274
Bengal	255	Central India	85
Bihar and Orissa	318	Central Provinces and Berar (including Irrigation Department) ..	244
United Provinces	273	Hyderabad	19
Punjab	192	Mysore (including Taluks) ..	229
Kashmir	41	Coorg	10
North-West Frontie Province ..	33	Madras (including Feudatory States)	516
Baluchistan	82		
Sind	14		

In 1920 the necessity of frequent inspections of raingauges was brought to the notice of the officers in charge of rainfall registration, and subsequent reports have indicated a decided improvement in this respect.

The following notes are based on the reports for 1926-27 of these officers :—

Burma.—The total number of rainfall recording stations during the year under report was 242 as against 243 last year. Of these, 18 are Meteorological Observatories, 30 are in charge of the Public Works Department, 2 are under the Director of Agriculture and the rest in charge of Civil Officers. The number of raingauges inspected during the year was 185 as against 218 in the previous year. The chief defect in exposure in many cases was, as usual, nearness to trees and buildings. Proper steps were taken to remove these defects. Administrative sanction was accorded for the removal and re-erection of raingauges from Papun and Mawlaik.

Assam.—There were 128 stations at the end of the year, including 7 observatory stations, as against 126 last year. Two new stations were opened during the year. The number of raingauges inspected was 111 as against 101 last year. The districts are generally well equipped with raingauges and other accessories.

Bengal.—The total number of stations at the end of the year was 256 as against 253 last year. Three stations at Dhupchanchia (Bogra) Mainmukh and Kaptai (Chittagong Hill Tracts) were newly opened during the year. Two raingauges one

in the Murshidabad and the other in the Khulna district were transferred to new sites. The number of stations inspected during the year was 224 as against 229 last year. The condition of the raingauges is reported to have been good on the whole.

Bihar and Orissa.—There were 318 raingauges (including 30 in the Feudatory States of Orissa and Chota Nagpur). Two new stations were started at Bhagaya and Kundahit both in the Santal Parganas. One station at Kurneul was closed during the year ; it will be substituted by a new station at Sahebganj. The number of stations inspected was 268 against 270 last year. The raingauges were generally well maintained.

United Provinces.—There were 284 rain reporting stations, including 16 meteorological observatories. Out of 268 stations under the supervision of district and canal officers 87 per cent. were inspected during the year as compared with 88 per cent. in the previous year. No new raingauge station was opened nor were any abolished but that at Oganpur was transferred to Debiabigh in the Bareilly district.

Punjab.—The total number of raingauges in charge of the Civil Department was 151. Two new raingauges were erected at Lawa and Tammon in the Attock District. 123 raingauges were inspected during the year by civil officers. The raingauges in charge of the Irrigation Department are also reported to be in good condition and regularly inspected by the officers of that Department.

North-West Frontier Province.—The total number of raingauges was 34 : of these 23 were inspected during the year and reported to be in good order.

Baluchistan.—There were 81 rain-recording stations (including those attached to observatories) maintained by the Civil and Railway Departments as against 80 last year. The raingauge station at Mirjawa was transferred to the charge of the Vice-Consul, Seistan but 2 more stations at Nari Bank and Ocepur were added to the list ; these 2 stations have been in existence before but were not submitting rainfall returns to the Provincial authority. The stations at Khushdil Khan Band and Lehri remained in charge of the Irrigation Department as in the previous year. The number of raingauges inspected during the year by the Civil and Railway Officers were 26 and 51 as against 23 and nil respectively in the previous year. The raingauges were all found to be in good order and the rainfall record satisfactory.

Bombay.—There were 338 stations including those in Sind and the Indian States : out of these 256 were inspected. In the Presidency proper, excluding the Indian States and Sind, there were 213 stations, of which 182 were inspected during the year as against 161 last year ; while out of a total of 64 stations in Sind 48 were inspected during the year as against 46 last year. In the Indian States, out of a total of 61 stations 26 were inspected as against 17 last year. The raingauges in all parts of the Presidency were in a satisfactory condition.

Rajputana.—Rainfall registration reports were received from all the States. There were 369 raingauge stations of which 323 were inspected during the year. The raingauges were generally in good condition.

Central India.—Reports on the rainfall registration were received from all States except Indore. There were 151 raingauges of which 144 were inspected in the course of the year. The raingauges were all in a satisfactory condition.

Jammu and Kashmir State.—There were 41 stations of which 8 are meteorological observatories. The number of stations inspected this year was 26 as against 18 last year.

Central Provinces.—The numbers of raingauges in the Central Provinces and Berar were 125 and 43 respectively, as in the previous year. A new raingauge has been erected at Dhamangaon where however rainfall registration has not yet commenced. The number of stations in the Central Provinces inspected this year was 351 as against 307 last year and 101 as against 122 last year in Berar.

Hyderabad.—There were 19 raingauge stations in all as in previous years. All the stations were inspected and found to be in good order.

Mysore.—Two new raingauge stations were opened during the year so that the total number in the State during the year was 229 as against 227 last year. Of these 77 are situated in District and Taluk headquarters and the rest in villages. The number of raingauges inspected during the year was 202 as against 214 last year.

Coorg.—The number of raingauges was 10. Seven stations were inspected during the year and found to be in good order.

Madras.—There were 494 stations (excluding meteorological observatories and Coorg stations) in the Madras Presidency and feudatory States. One new station was opened and one was closed. The number of stations inspected during the year was 449 as against 461 last year. The raingauges were all in good condition.

Baroda.—No report has been received and it is understood that none can be sent for this season's work.

Heavy Rainfall Reports.—Heavy rainfall is occasionally so very local that small areas can have as much as 10″ without the Daily Weather Report conveying the least suggestion of the heavy inundation. In order that such useful data might be promptly available for the Daily Weather Report it was arranged in 1921, with the approval of the Government of India, that reports of 5″ or more of rainfall should be telegraphed to Simla from raingauge stations at district headquarters throughout the country. The number of such telegrams received during 1926-27 was 190 as compared with 134 in the previous year.

Snowfall Registration.—Information as to the amount, distribution and time of occurrence of snowfall in the Himalayan and Afghan mountain areas was on the whole tolerably complete, and the thanks of the Department are due to the various officers who collected and forwarded the reports.

Supply of Information, Publications, and Library.

20. The ordinary channels for the supply of information to the public are the routine publications mentioned below. From time to time however special information is also supplied to the meteorological departments of England, Australia and Egypt. Climatological and other data, at times involving special calculations, are also provided for sanitary and other officers of Government as well as for those private firms who are willing to pay for the service. It may also be mentioned that the seismic data collected at Simla, Calcutta, Bombay and Kodaikanal are sent to the Seismological Committee of the British Association.

The routine publications of the Department are shown at length in the Administration Report for 1922-23.

The Daily Weather Telegram was despatched to subscribers daily about noon, and the weekly rainfall summary was supplied to the *Gazette of India.*

The Weekly Weather Report, containing matter similar to the Weekly Summary printed in the *Gazette of India,* was published by this department during the monsoon period, and supplied to about 36 subscribers and also to the Press.

The number of institutions, etc., on the distribution lists of the Department was 337 at the end of the year.

The following publication was issued during the year :—

" Storm tracks in the Arabian Sea ", by C. W. B. Normand.

Books, periodicals and pamphlets either purchased or received as presentation copies in the department's libraries at Simla and Calcutta during the year

numbered 780. The total number of books and pamphlets which have been catalogued and classified in the Simla library was 9,690 on the 31st March, 1927.

GAZETTED STAFF : APPOINTMENTS AND LEAVE.

21. Four new permanent appointments of Meteorologist and three of Assistant Meteorologist were sanctioned during the year, and the part-time posts of Meteorologist at Calcutta and Madras were abolished. One post each of Meteorologist and Assistant Meteorologist was assigned to Alipore Observatory in connection with the transfer of storm warning duties from Simla to Calcutta. One Meteorologist's post was added to the Agra Upper Air Observatory's establishment in order to allow more adequate study of the upper air information now available, and another to the Simla Office establishment for the Daily Weather Section, while an Assistant Meteorologist's post was assigned to Madras in place of the part-time Meteorologist's post, which had for long existed there. The other posts of Meteorologist and Assistant Meteorologist were created later in the year in connection with the opening of a new Meteorological Office at Karachi. The changes in personnel have been as follows :—

Mr. J. H. Field was granted leave on average pay for 8 months combined with leave on ½ average pay for 4 months from the 3rd March 1927, with permission to retire from the service on the expiry of the leave.

Dr. C. W. B. Normand on return from leave for 9 months assumed charge of his office on the 3rd January 1927 and was appointed to officiate as Director-General of Observatories with effect from the 3rd March 1927 during the absence on leave of Mr. J. H. Field.

Dr. S. K. Banerji on return from leave for 3½ months assumed duty at Simla on the afternoon of the 11th April 1926. On transfer from Simla he was posted to Bombay from the 8th January 1927, relieving Dr. K. R. Ramanathan.

Prof. P. C. Mahalanobis on the abolition of his post relinquished charge of the office of part-time Meteorologist, Calcutta, on the 9th April 1926 (afternoon).

Mr. V. V. Sohoni on transfer from Simla was posted to Calcutta with effect from the 10th April 1926 as full-time Meteorologist there.

Dr. B. N. Banerji on transfer from Simla was posted to Karachi from the 19th December 1926.

Dr. S. N. Sen was granted leave on average pay for 10 days from the 17th June 1926.

Dr. K. R. Ramanathan, temporary Meteorologist, was appointed on probation to be a Meteorologist in the Indian Meteorological Service with effect from the 10th April 1926. On transfer from Bombay, he was posted to Agra with effect from the 11th January 1927.

Drs. K. J. Kabraji, S. K. Pramanik, and S. C. Roy, were appointed on probation to be Meteorologists in the Indian Meteorological Service with effect from the 15th February 1927, 25th February 1927 and 7th March 1927, respectively.

Mr. M. G. Subrahmanyam was granted leave on average pay for 3 months and 5 days with effect from the 24th August 1926 and, in continuation, leave on medical certificate for 3 months and 15 days on average pay. Mr. Hans Raj Puri, was appointed to act as Assistant Meteorologist during his leave from the 24th August to the 14th September, Mr. L. A. Ramdas, from the 15th September to the 21st October, Mr. Nigahia Ram from the 22nd October to the 11th December 1926 and Mr. P. R. Krishna Rao, from the 3rd January 1927.

Mr. S. Sitaramayya remained on leave throughout the year. Mr. Mukand V. Unakar, continued to act as Assistant Meteorologist in this vacancy upto the 21st October 1926 and Mr. L. A. Ramdas, from the 22nd October 1926.

Mr. V. Doraiswamy Iyer on transfer from Simla was posted to Calcutta with effect from the 1st April 1926.

Mr. Barkat Ali was granted leave on average pay for 3 months with effect from the 29th November 1926.

Rao Sahib Mukand V. Unakar, was appointed to a permanent post of Assistant Meteorologist with effect from the 22nd October 1926. He was granted leave for 1 month and 24 days with effect from the 14th March 1927. Mr. P. R. Krishna Rao, was appointed to act as Assistant Meteorologist during his absence on leave with effect from the 16th March 1927.

Dr. S. R. U. Savoor on the abolition of his post relinquished charge of the offices of part-time Meteorologist and Deputy Director, Madras Observatory on the 1st of September 1926 and Mr. C. Chengalvoraya Mudaliar was appointed to officiate as Assistant Meteorologist, Madras, with effect from the same date.

Mr. A. A. Narayana Aiyar, was appointed on probation to be an Assistant Meteorologist and was posted to Madras with effect from the 16th October 1926, relieving Mr. C. Chengalvoraya Mudaliar.

Mr. A. K. Roy, was appointed on probation to be an Assistant Meteorologist with effect from the 6th September 1926 and posted to Simla.

Dr. L. A. Ramdas, Officiating Assistant Meteorologist, *vice* Messrs. M. G. Subrahmanyam and S. Sitaramayya on leave was posted to Karachi with effect from the 27th December 1926.

Mr. P. R. Krishna Rao, was appointed Officiating Assistant Meteorologist at Simla, *vice* Mr. M. G. Subrahmanyam and Rao Sahib Unakar on leave.

Concluding Remarks.

22. The Meteorological Department owes a large part of its usefulness to the sympathetic assistance it receives from other departments. Civil Surgeons and other officers of Government Departments, as honorary superintendents of observatories and in other capacities, help in the meteorological work ; the Posts and Telegraphs Department assists in the rapid transmission of meteorological information ; at the same time they allow their employees to act as observers. The Indo-European Telegraph Department, also, by giving free transit to the daily messages from the Persian observatories, places a large amount of most useful information at the disposal of the Meteorological Department. Weekly telegrams are received from April to October from the Director, Royal Alfred Observatory, Mauritius and from the departmental observatories at Zanzibar and Seychelles. These telegrams give valuable information of the weather conditions in the Indian Ocean, and the department is indebted to the officers indicated for the punctual transmission of the information. Thanks are further due to the Director of Royal Alfred Observatory for his courtesy in placing the meteorological data of that observatory at our disposal.

The department is greatly indebted for important information on meteorological conditions prevailing before and during the southwest monsoon to the Controller, Physical Department, Cairo ; the Directors of the observatories at Buenos Ayres, Santiago and Batavia ; the Astronomer Royal, Cape Town ; Director, L'Observatoire Physique Central, Leningrad ; the Secretary, Friends' Industrial Mission, Banani Pemba, Zanzibar ; the Principal Medical Officer, Tanganyika Territory, Dar-es-Salaam ; the Commonwealth, Meteorologist Melbourne ; Director of Agriculture, Salisbury, Rhodesia ; Chief of the Weather

Bureau, Washington ; and to the various officers around the Indian frontiers who have collected and supplied valuable snowfall information.

The thanks of the Department are due to the Superintendent of Colombo Observatory for the very useful help he has rendered from time to time in connection with storm warning work. The Department is also grateful to the Director, Koninklijk Magnetisch en Meteorologisch Observatorium, Batavia, Java who has arranged for taking and telegraphing to Simla daily observations from Sabang in Sumatra during the cyclone months April, May and October to December. The Department would also like to take this opportunity of recording its appreciation of the valuable help rendered by the Public Service Commission in the selection of Meteorologists to fill three vacancies in the gazetted ranks.

C. W. B. NORMAND,

Offg. Director-General of Observatories.

SIMLA ;

The 12th July 1927.

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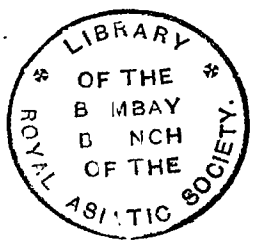
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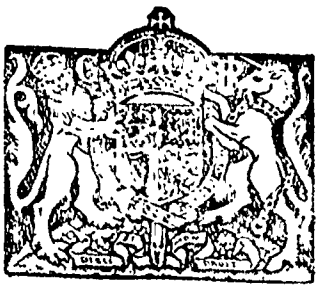

Report on the Administration of the Meteorological Department of the Government of India in 1926-27.

SIMLA
GOVERNMENT OF INDIA PRESS
1927

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Report on the Administration of the Meteorological Department of the Government of India in 1927-28.

SIMLA
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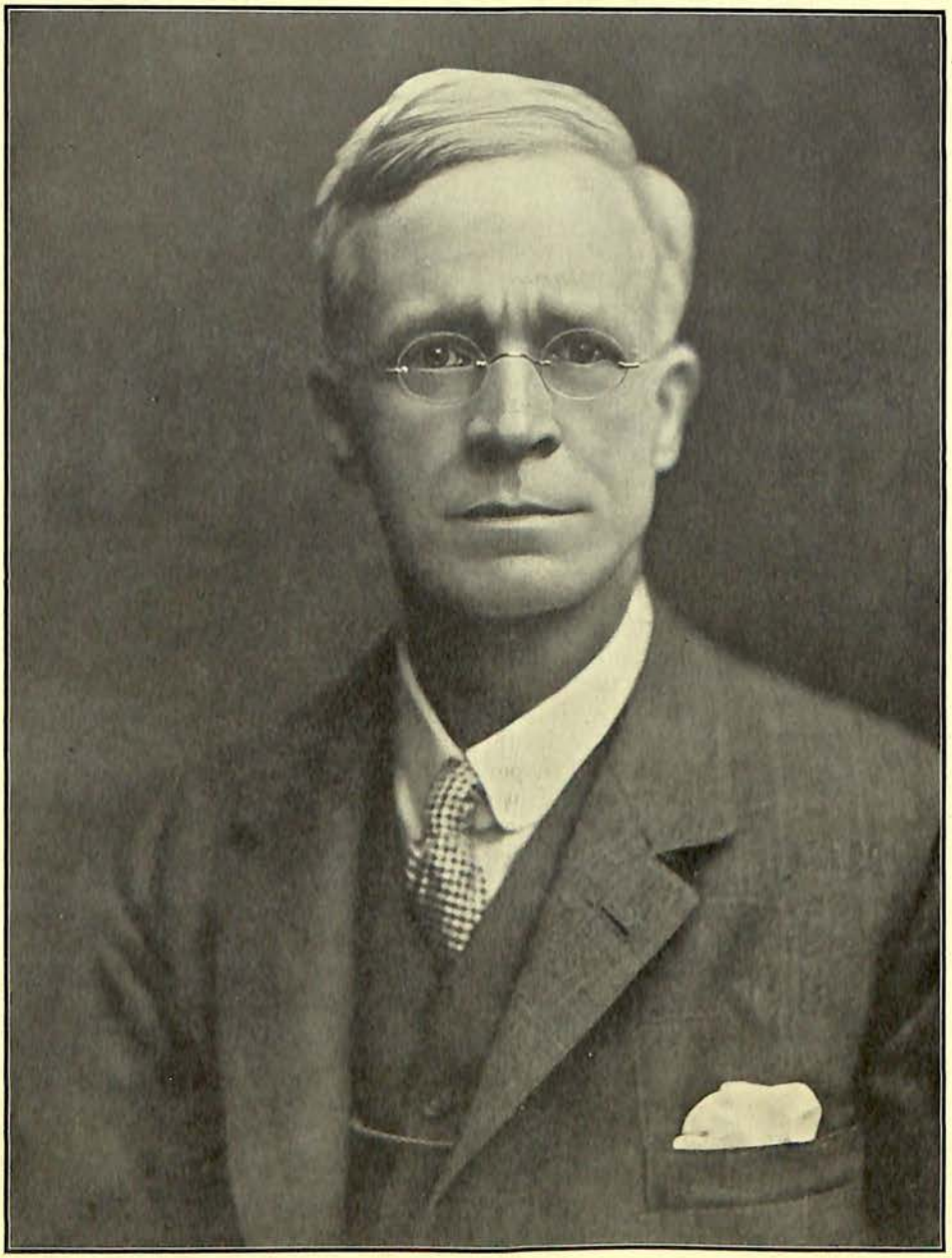
1928.

With the compliments

of the

Director-General of Observatories.

THE RETIRING DIRECTOR-GENERAL
OF INDIAN OBSERVATORIES.



J. H. FIELD, 1924—1928.

Photo.-engraved & printed at the Offices of the Survey of India, Calcutta, 1928.

Report on the Administration of the Meteorological Department of the Government of India in 1927-28.

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Chief features of the year.

The Director-General of Observatories, Mr. J. H. Field, after being on leave throughout the year, retired from service in March 1928 under the superannuation rule. He joined the department in 1904 and became Director-General in December 1924. His name will always be associated with the start of systematic upper air observations in India. The Upper Air Observatory at Agra, founded in 1914, is his creation and there he found the work which was most to his liking. On his transfer six years ago from that observatory to the less congenial administrative work in Simla, he brought the enthusiasm, tireless thoroughness and critical acumen that had always characterised his scientific activities and vigorously advanced various new schemes for the development of Indian meteorology. The value of his short regime may be seen in the increase of gazetted staff at headquarters and Calcutta, the extension of upper air work in India and neighbouring countries, and the construction of the new headquarters buildings at Poona at a cost of about 9½ lakhs. During his service he devised several upper air instruments and methods of observation, published scientific memoirs on upper air researches and on the exposure of thermometers in India and indicated a method of forecasting the winter rainfall in northern India from upper air data. By Mr. Field's retirement the department have lost a keen and indefatigable head, who to the end of his service retained an unabated zeal for work and commanded the respect and admiration of his staff to an unusual degree.

2. The pressure of work at headquarters during the year under review was heavy. Correspondence and conversations with the architects regarding the new Poona buildings formed a large abnormal item, and the scheme of transfer of headquarters from Simla to Poona had also to be worked out. On the other hand officers were mostly recent recruits under training and many of the trained north India clerks sought transfers to offices in Simla and Delhi in order to remain in their native province, so that a large portion of the work fell on the shoulders of a comparatively few experienced officers and clerks.

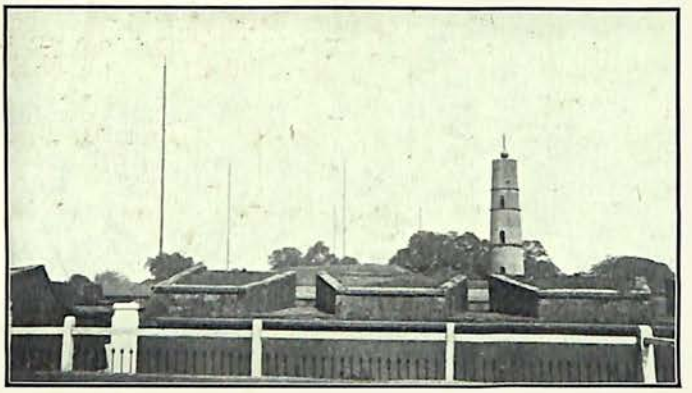
3. Progress in the construction of the new headquarters' buildings at Poona was somewhat hampered by delayed deliveries of the steel used in the base of the tower. The buildings were not finished by the 31st March, the contracted date of completion, but sufficient office accommodation was available on the ground and first floor of the main building to enable a start to be made, under difficulties, in the transfer of clerks from Simla to Poona. The move was arranged to take place

in batches, and the first section began work there towards the end of March. The first all-India Weather Report from Poona was published on the 1st April 1928.

4. The provision of adequate meteorological information to the proposed Imperial Airships on their flights between Basra and Karachi was one of the outstanding questions to be considered during the year under review. The scheme accepted by Government contemplates that action be taken in three distinct and separate stages, the immediate, on which action was taken on the lines explained below, the intermediate, to be completed before the experimental ships carry out their trials between Egypt and India, and thirdly the ultimate action, for the frequent and regular service which is not expected to start before 1931. On the first stage of the scheme for which Government sanctioned Rs. 68,000 action was almost completed by the end of the year ; additional surface observatories were established along the route ; pilot balloon observations to determine the upper air current were started at Bahrein, Muscat and Gwadar ; and co-operation was extended to ships plying in the northeast Arabian Sea and the Persian Gulf. The Karachi Meteorological Office has thus been placed in a position to gather and study an increased supply of weather information from the Persian and Mekran coasts and the neighbouring sea areas. At Karachi itself there are special meteorological problems to be studied in connection with landing and mooring airships, problems particularly of wind and gustiness and vertical air temperature gradient in the first 250′ above ground. For these purposes a mast 260′ high was erected at the Airship Base, Karachi, and special instruments made in England will soon be mounted on it. A small office building and quarters for three meteorological assistants have been completed at the Airship Base. It is hoped therefore that experimental data with regard to vertical temperature gradient and gustiness will soon be available at Karachi. Personal contact and discussion with British airship officials was fortunately made possible through the visit to India of the Director of Airship Development and the Superintendent of Airship Meteorology of the London Meteorological Office. The latter visited the Simla Office and both visited Agra and Karachi Offices.

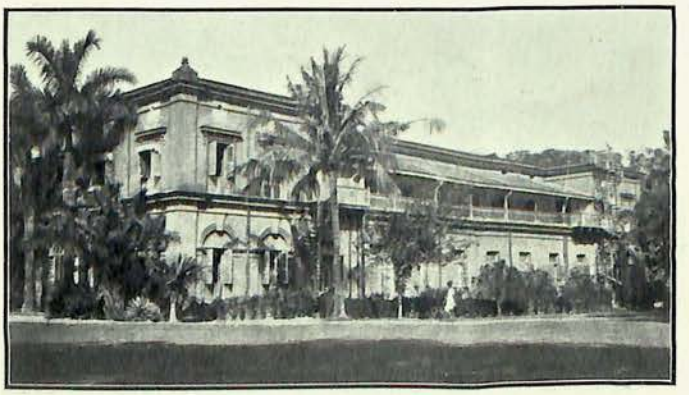
5. Of the other new schemes which engaged the attention of the department, possibly the most important is that for the study of nor'westers. These violent local storms cause considerable loss of life and property almost every year in northeast India. Their origin and nature is very imperfectly understood and their study requires the collection of more frequent and numerous weather observations than have been recorded in the past. A scheme for detailed weather observations in northeast India for a period of two years was, therefore, drawn up and submitted to the Government of India for approval. A proposal for reviving the post of Assistant Director of the Kodaikanal Observatory was also referred to the Government of India and has been sanctioned with effect from 1928 ; the restoration of this post is needed to allow Kodaikanal to continue to take the same creditable part in advancing wor'd's knowledge of solar physics as in the past. Another proposal concerns the extension of office buildings at Agra and the provision of residential quarters for the second meteorologist of that observatory, where these facilities, if provided, will accelerate the important upper air research work which is being carried on.

6. A series of weekly meetings was held at headquarters under the chairmanship of the Director-General, at which recent technical papers published by foreign meteorologists were discussed by officers. Also, in view of the fact that most of the newly recruited clerks are science graduates, courses of lectures on elementary meteorology were delivered by officers at headquarters for the benefit of the assistants. The Director-General conducted a course on modern European methods of analysis of weather charts, and successful attempts were made by forecasting officers to apply modern theories to the study of India weather charts. Diagnosis of weather charts by such means indicated that weather was



FORT WILLIAM,
TIME-BALL AND
WIRELESS STATION.

ALIPORE
OBSERVATORY.



METEOROLOGICAL
OFFICE,
ALIPORE.

CALCUTTA.

Photo.-engraved & printed at the Offices of the Survey of India, Calcutta, 1928.

sometimes, at least, the outcome of conflicts between air masses having different histories and physical properties and the new ideas were certainly helpful in daily forecasting under Indian conditions and the issuing of heavy rainfall warnings.

7. A new series of technical papers has been introduced entitled " Scientific Notes ".

8. The Alipore Observatory, Calcutta completed its 50th anniversary, having been established in the year 1877.

MARINE METEOROLOGY AND STORM WARNINGS.

9. *Marine Meteorology.*—The recent increase in the gazetted staff has made it possible to earmark one meteorologist and two clerks as the nucleus of a new section at headquarters for the study of the meteorology of the Indian sea areas. The staff were under training during the year.

10. The utilitarian services of warnings for storms at sea were rendered as usual. Wireless weather messages from ships at sea and extracts from weather logs of ships calling at the principal ports on the Indian Sea board constituted chief sources of marine data available to the department. Radio weather messages from ships are primarily meant for supplementing the observations from the coast stations. In the absence of adequately numerous observations from sea areas it becomes extremely difficult at times to draw correct conclusions regarding the position, movement and intensity of storms. The difficulty is more keenly felt in connection with disturbances in the Arabian Sea for which inferences have had to be drawn in the past from very insufficient observations from the west coast line of India. It is however gratifying to note that the co-operation of ships in the matter of wireless weather messages is showing steady improvement from year to year. Thus the number of ships' messages from the Bay and the Arabian Sea totalled 4,835 as against 4,282 in the previous year and 956 in 1921-22. The department gratefully acknowledges the assistance rendered by commanders of ships who took part in this service, and would especially mention the following steamers from each of which 40 weather messages or more were received during the year :—

Akbar ..	.. 62	Ekma ..	.. 40	Nankin ..	.. 44
Angora ..	.. 66	Elephanta ..	.. 44	Nurjehan ..	.. 58
Arankola ..	.. 42	Ethiopia ..	.. 87	Nurmahal ..	.. 43
Aronda ..	.. 65	Havildar ..	.. 63	Nowshera ..	.. 45
Aungban ..	.. 102	Hosang ..	.. 42	Pundit ..	.. 53
Badarpur ..	.. 150	Jalapalaka	.. 43	Razmak ..	.. 49
Bankura ..	.. 44	Jehangir ..	.. 62	Shajehan ..	.. 149
Barala ..	.. 50	Khosrou ..	.. 78	Singu ..	.. 71
Baroda ..	.. 48	Kohinoor ..	.. 54	Streefkerk ..	.. 45
Barpeta ..	.. 229	Maharani ..	.. 117	Varsova ..	.. 48
Beme ..	.. 181	Mandala ..	.. 50	Vita ..	.. 94
Cocanda ..	.. 96	Meerkerk ..	.. 40		

11. The co-operation between ships' captains and this department is, therefore, increasing satisfactorily, but, even yet, the officers in charge of warnings in this department often feel the want, at critical times, of ships' observations specially from the Arabian Sea and find themselves compelled to draw their inferences and base their broadcast messages on coast observations alone. It would be most helpful if co-operating captains could induce others to take a share in this service of information from the sea. It is worthy of note that a message, which may appear to be colourless by itself, is frequently of great use, when considered along with other observations plotted on a chart. The urgent necessity of further co-operation of ships in all parts of the Arabian Sea must again

be emphasised and the Port officers on the west coast are especially invited to assist this department in propaganda work amongst ships' captains.

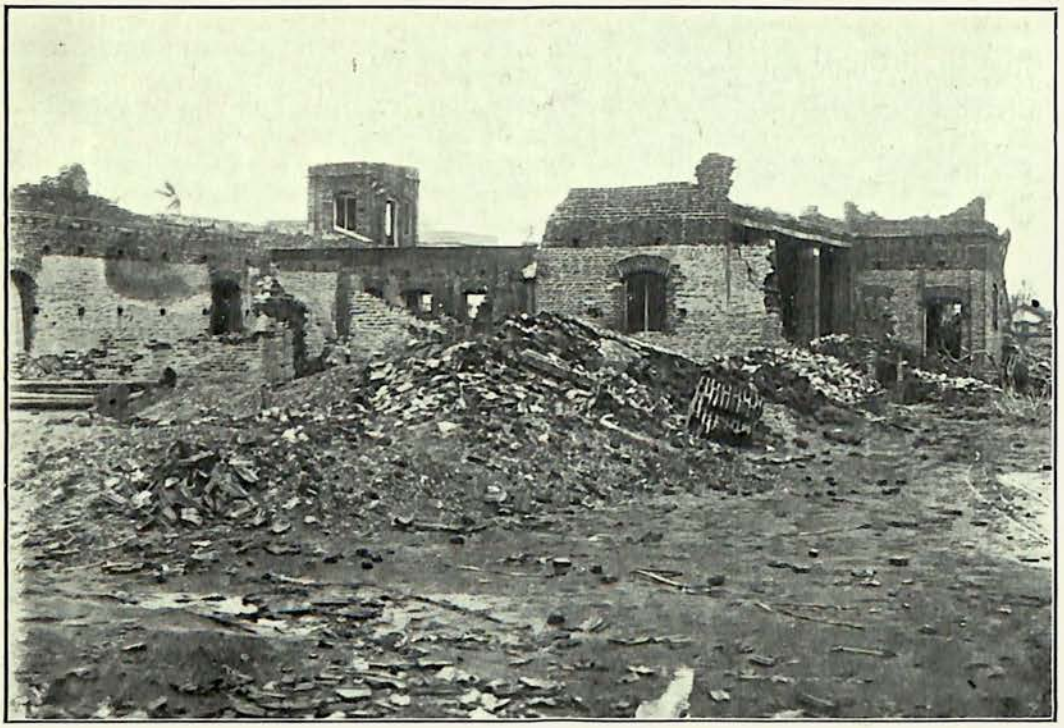
12. The practice of lending instruments to a few ships was continued during the year, and at the end of the year 12 captains were supplied with meteorolgical instruments on loan. It may be noted that recipients of these instruments regularly forward weather logs collected in Indian waters to this department. Shipping firms also co-operate with the department in helping to augment weather information from the high seas. Special mention may be made in this connection of the willing help rendered from time to time by Captain E. Trott, Marine Superintendent of the Asiatic Steam Navigation Company and Captain H. J. Rouse, Marine Superintendent of the British India Steam Navigation Company.

13. Apart from ships' wireless messages, an important source of data is the log extracts collected in Calcutta and Bombay. The observers of the Time-Ball and Tidal Observatory of the Rangoon Port Commissioners also have continued their useful collection of ships' data. Occasionally, in special cases logs of steamers with experience of disturbed weather are collected at Madras ; the Colombo Port authorities also help similarly whenever requested. A total of nearly 3,000 logs was recorded at the end of the year.

14. *The system of storm warning for ports and shipping.*—The warning of ports and shipping in the Arabian Sea against the approach of cyclonic storms, or of bad weather, was done from Simla, while similar warnings for disturbances in the Bay of Bengal were issued by Calcutta. At present the storm warning list consists of 34 ports on the west coast and 28 ports on the Bay of Bengal. In addition to these regular ports, there are 8 river ports and 14 River Police Stations and 41 District Police Stations which have to be warned by Alipore in connection with disturbed weather at the head of the Bay of Bengal. Of the Bay ports 12 are provided with additional information regarding the particular areas in which weather is disturbed by a special system of ' locality signals '. Shipping at sea is also supplied with the latest weather information by means of wireless bulletins, broadcasted twice daily or more frequently whenever necessary. The radio stations at Bombay, Karachi and Aden serve the Arabian Sea area, while those at Calcutta, Rangoon and Madras serve the Bay of Bengal area. The wireless station at Matara (Ceylon) serves both the areas.

The number of warning messages for ports and the two sea areas issued by the department during the year was 8,712. These messages include all radio weather broadcasts from the 7 wireless stations and all warning telegrams by land-line during storms or periods of disturbed weather to the Bay of Bengal and the Arabian Sea ports.

15. *Warning to ports and shipping in the Bay of Bengal.*—During the year warnings were issued for 35 periods of disturbed weather. On two occasions the disturbances developed into moderately severe storms and in two other cases into cyclones. The earlier of the two cyclones formed in front of the southwest monsoon current which had made an advance in the south of the Bay in the third week of May. The activity of the monsoon increased gradually and had become well marked by the 24th, when a trough of low pressure lay over the region extending from northwest India to central Burma. Subsequently a low pressure area appeared over the mid-Bay and developed into a deep depression on the 31st. The disturbance had intensified into a storm by the next morning with its centre near Lat. 17°—30′ N., Long. 90°—45′ E. The storm moved slowly in a northwesterly direction and its centre crossed the south Bengal coast on the afternoon of the 4th June at a very short distance to the east of Saugor Island where the unusually heavy fall of 14″ of rain occurred in a day. Several steamers passed into the storm area and experienced gales and hurricanes with exceptionally heavy seas.



CYCLONE DAMAGE AT NELLORE, NOVEMBER, 1927.

Photo.-engraved & printed at the Offices of the Survey of India, Calcutta, 1928.

The next cyclone was that which passed over Nellore on the night of the 1st November. Unsettled conditions associated with showery weather appeared to the southwest of the Andamans on the 27th October and developed into a depression on the 29th. On the morning of the 30th, the storm centre lay near Lat. 11°—30′ N. Long. 88° E. The storm moved in a westnorthwesterly direction and passed over Nellore shortly after 19 hrs. on the 1st November. This storm caused gales and heavy rain squalls in the sea areas and while crossing the coast affected Madras and Nellore very severely, the breakdown of communications being one of its most serious features. In many places railway lines were wrecked, roofs blown off buildings, bridges washed away and telegraph lines damaged. From a report received from the Collector the weather experienced at Nellore at the time was as follows :—

> "Rain commenced at 10 hrs. and from 13 hrs. wind and rain began to increase ; at 5-30 P.M., the virulence of the wind was unbearable and from 6 to 7 P.M., none could stir out ; between 7 and 7-30 P.M., there was a lull for 10 or 15 minutes. There was no rain or wind during the lull and the sky was clear. The wind before the lull came from NNW, but immediately afterwards from SSE ; the storm after the lull was worse than before it."

Regarding the damage the Collector observes :—

> "The scene round Nellore and Kovur resembled that of devastated France. Huge trees were blown down, trees were stripped of their foliage. The wind had a blighting effect apparently on living trees. Except in houses with terraced roofs, roofs were stripped of their tiles. Thatched houses lost their roofs. Mud walls generally withstood the wind and rain. From the reports received up to date it may safely be inferred that the cyclone was at its worst within a circle having Nellore as its centre and radius of 25 miles. Beyond these limits the storm was less intense and caused less damage. Up to date reports of nearly 200 deaths have reached me. Deaths for the whole district are not likely to exceed 300. The loss of life is due to people being buried under the debris from falling houses and to exposure."

16. Reports on the working of the warning system were received by the Meteorologist, Calcutta, from 26 Port Officers on his warning list. All of them stated that the warnings were satisfactory. In reply to the queries made by the Meteorologist in the circular letter issued to all Port Officers, the Harbour Master, Calcutta wrote :—

> "The warnings were timely, useful and satisfactory in every respect. I cannot answer this question without expressing my great appreciation of the excellent work done by your department and the actual assistance your warnings and informations have been to me in my position as Harbour Master."

17. *Warnings to ports and shipping in the Arabian Sea.*—The west coast ports are warned not only for storms but also for squally weather, especially at the beginning of the monsoon. During the year warnings were issued for 45 periods of disturbed weather ; disturbances developed into depressions on 3 occasions and twice into storms of moderate to severe intensity. The first storm began as a depression, which lay to the west of the Laccadives on the 31st May. This depression subsequently developed into a storm and was centred near Lat. 18° N., Long. 62° E., on the morning of the 6th June. It moved in a northwesterly direction and had disappeared on the Arabian coast by the 10th. The second storm was more severe and was responsible for unusually heavy loss of life at sea. It had its origin in a depression which formed in the mid-Arabian Sea on the morning of the 11th November. By the next morning it had developed into a storm with centre about two hundred miles southwest of Bombay and crossed the coast between Ratnagiri and Bombay on the morning of the 13th. The storm

did enormous havoc to coastal craft, and caused the loss of two steamers, the Tukaram and the Jayanti with more than 200 passengers on board.

For the Arabian Sea area reports on the working of this marine warning system were received from 14 officers on the warning lists. All of them considered the warnings to be satisfactory.

The following statement appeared in the "Daily Gazette", Karachi of the 9th April 1927 :—

> "A message from Simla says that a gale is breaking over the Baluchistan and Kathiawar coasts, and very rough weather is to be expected this afternoon and to-night off Karachi. The local cautionary signal No. 3 has been hoisted as a warning to navigators. As we go to press a gale and dust storm from the west is springing up."

In connection with the warning telegrams issued during the Arabian Sea storm of November, 1927, the Collector of Salt Revenue, Bombay, in his letter dated the 8th February 1928, wrote :—

* * * * * * *

As regards the damage to shipping considering that—

> (*a*) the area affected was considerable, (*b*) the storm occurred during the busy part of the fair season, and was of an unduly severe type and (*c*) the country crafts that ply on the coast at this time are with hardly an exception, overloaded, the fact that casualties occurred to only about 20 country boats and that too on the coast beween Bombay and Jaigad, a stretch 111 miles long out of the total coast line of 334 miles from Bombay to Bhatkal goes to show that the storm warning arrangements had the desired effect. As a matter of fact a large number did take refuge in safe anchorages as soon as the warning signal was exhibited.

* * * * * * *

The following remarks from the Port Officer, Bhavnagar may also be quoted :—

> "In every respect the messages have been timely during the past year and have proved of great value, both to the steamers and country vessels."

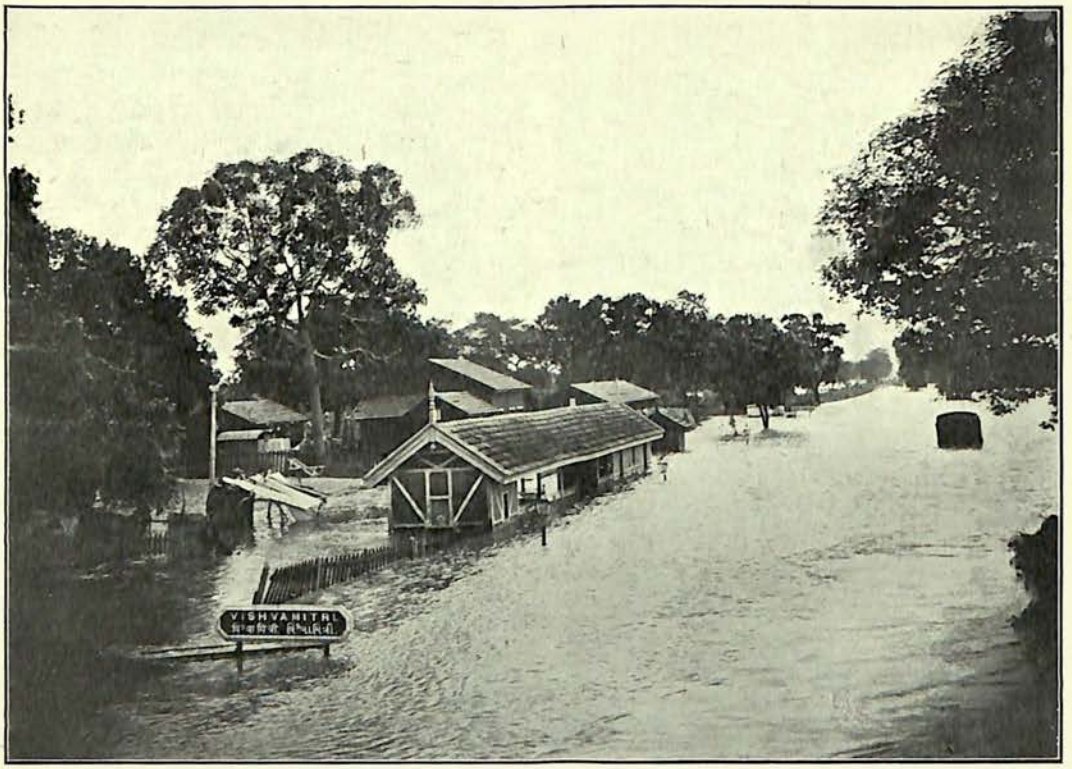
Inland Weather Warnings.

18. Warnings for heavy rain on land were issued during the year by both Simla and Calcutta. Most of the officers on the warning lists are district officers and officers of the irrigation, railway and other departments ; the total number at the end of the year was 207, as against 194 in the previous year. In addition, there were 24 officers of the Telegraph Department, who generally required warnings for strong winds.

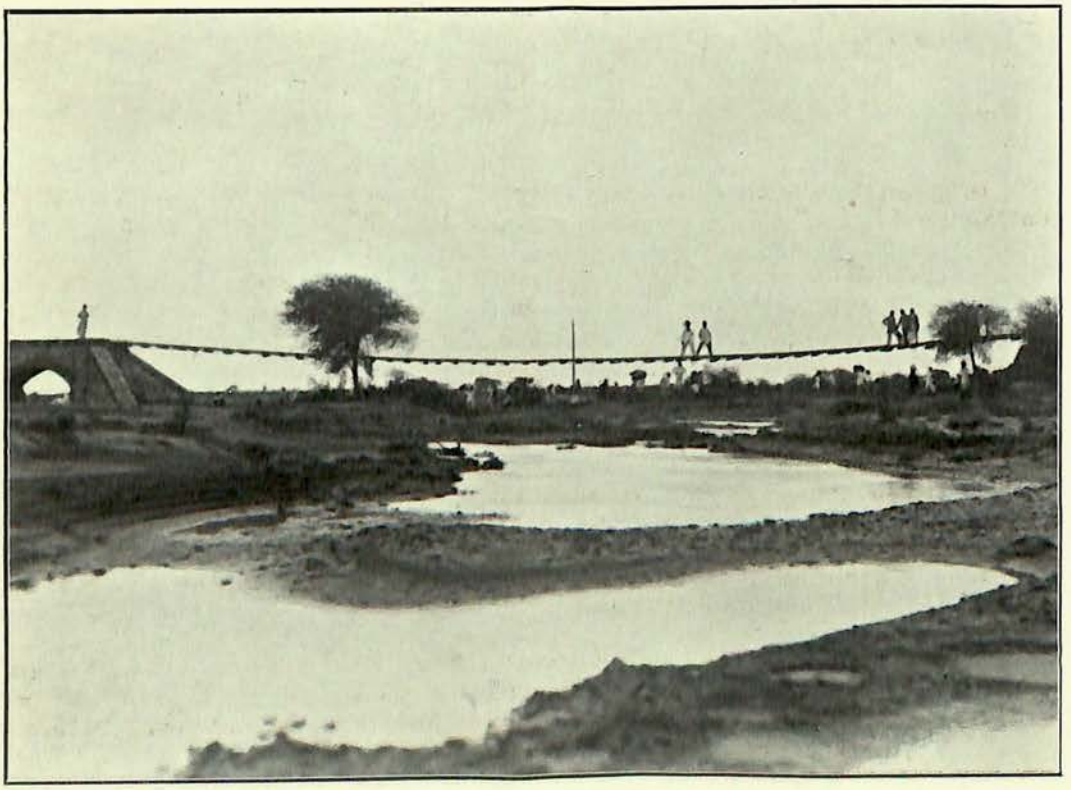
The southwest monsoon months were marked by heavy localised rainfall causing serious floods from time to time in various parts of northern India particularly in Gujarat and Orissa. The warnings for heavy rain were issued in the past only to officers included in the warning lists of this department. With a view to make the information available to the public through the press, the warnings were included from November last at the end of the Daily Weather Telegram and now obtain wide circulation.

The number of special inland forecasts and warning messages issued by the Department during the year was 2,520. In addition 954 telegrams of actual heavy rainfall were sent by meteorological observers direct to various officers.

At the end of the year 136 reports on the working of this system were received from recipients of these warnings ; 125 stated that the warnings were



RAILWAY STATION, BARODA STATE RAILWAY.



RAILWAY EMBANKMENT WASHED AWAY IN KATHIAWAR.

Photo-engraved & printed at the Offices of the Survey of India, Calcutta, 1928.

satisfactory, while the remaining 11 offered suggestions or minor criticisms which have received consideration.

On the whole a comparison of the inland warnings with the actual subsequent rainfall, or the tracks of storms across the country, show that most of the warnings issued proved useful to the recipients. The Gujarat floods referred to above were caused by heavy rain which began in the Ahmedabad district on the night of the 23rd-24th July and became general in Baroda and Gujarat on the next night. The rain lasted for five days and reached its maximum intensity on the 26th and 27th. Timely warnings for heavy rainfall were issued to officers on the warning lists. The following are some of the opinions of local officers and extracts from comments in the Press :—

Executive Engineer, Ahmedabad District.	Warnings of July 24 and 27 were timely and enabled some precautions to be taken but storm so heavy that no precautions proved of avail.
Political Agent, Palanpur ..	Warnings most timely and useful.
Dewan, Rajpipla	Warning received timely on same day to enable us to inform other stations in the State.

The " Pioneer ", Allahabad, dated 3rd August 1927 commented as follows :—

> " * * * It will be noted that once again the Meteorological Department proved its worth. A telegram from Simla gave Baroda warning of the impending cyclone 24 hours in advance and thus enabled the authorities to take measures greatly reducing the death roll ".

Baroda Correspondent's account in the " Pioneer " of the same date :—

> " * * * It was fortunate that a telegram from Simla gave warning of the impending cyclone about 24 hours in advance, and this was, in a great measure, responsible for the comparatively small number of deaths at any rate in Baroda City."

In connection with a warning telegram issued by the Meteorologist, Calcutta, the Divisional Engineer, Telegraphs, Akyab Division, wrote :—

> " The warning was timely and very satisfactory for I was able to warn all Telegraph Linemen at all stations to be in readiness. in case the telegraph line connecting India with Burma along the Arakan Coast was damaged.
>
> I must say that I was very surprised with the accuracy of your reports."

The Collector of Cuttack in one of his letters wrote :—

> " The warnings were of considerable use to the local officers in dealing with the situation arising out of the Orissa floods."

In a letter, dated the 17th December 1927 the District Engineer T. T. Conversion, Tumsar Road, wrote :—

> " The warning of 5-10-27 was most timely and thanks to its receipt, heavy machinery about to be placed at the head of the river Bawanthari was delayed and pumps, etc., already there were removed before the heavy flood arrived, which amply justified your warning."

The Executive Engineer, Northern Division, Ganges Canal wrote in his letter, dated the 9th January 1928 :—

> " On two occasions these warnings were particularly useful. The first encouraged me to keep the Ganges canal closed although the lower Divisions were insistently asking for its opening and the second enabled my staff to be ready for unexpected floods."

Offices and Observatories.

19. *Headquarters Office, Simla.*—The gazetted staff was strengthened during the year by the addition of 4 Meteorologists and 2 Assistant Meteorologists. It was thus possible to reorganise the work on a more satisfactory basis than hitherto by dividing the office into 7 sections, *viz.* :—

(1) General ; (2) Weather ; (3) Observatories ; (4) Marine ; (5) Instruments ; (6) Upper Air ; and (7) Library and Enquiries.

The new schemes originating in this office and several aspects of the normal work, *e.g.,* storm and flood warning, have already been mentioned in earlier sections of this report. The weather forecasts issued from this office for aviation purposes exceeded 100. The most important occasions in connection with which forecasts were issued were the eastern cruise of the four R. A. F. flying boats and the various attempted non-stop flights from Europe to India and the Far East.

Agra.—An extension of upper air work by the addition of 15 pilot balloon stations was sanctioned by Government last year. Arrangements were made by the Agra Observatory to recruit and train up the necessary staff and collect together adequate equipment for these additional stations. In addition a new pilot balloon station was started at Ambala in March 1928 to replace that at Simla, which was stopped on account of the transfer of the headquarters office. The Agra Observatory also started towards the end of the year three new upper air stations, namely, Gwadar, Muscat and Bahrein, along the flying route from Basra to Karachi.

The test of airship fabrics which was first started in 1925 was also carried out this year on a further consignment of fabrics received from the Royal Airship Works, Cardington. All past upper air data collected on days fixed by the International Commission for the investigation of upper air were worked out in the form recommended by the Commission and forwarded to them. Certain statistics of upper air data were also supplied to the British Meteorological Office.

An investigation on temperatures acquired by iron rails exposed to sunshine was carried out and a report was drawn up. A comparative study of temperature and humidity recorded inside Stevenson screens placed at different heights, which was started in the previous year, was continued. Attempts were made to investigate the winds in the stratosphere with balloons made out of Vultex tissue and a fair amount of success was achieved. The observatory also continued its researches and with the help of its sub-stations collected valuable information regarding the structure and circulation of the upper layers of the atmosphere. Records of air pressure, temperature and humidity up to heights of 12 or 15 miles were obtained at Agra by means of sounding balloons ; about 55 per cent. of those recovered during the year reached the stratosphere. It was found that during the monsoon months temperatures

over Agra between 3 and 14 kms. practically follow the saturation adiabatic corresponding to a surface temperature of 297°A. These upper air temperatures are 5-10° higher than those found in the same months over Batavia or the Atlantic Ocean between latitudes 20° and 40° N. The examination of the higher flights confirm the general conclusion arrived at last year, namely, that the height of the tropopause is about 12 miles above sea-level in Indian latitudes, that above the tropopause temperature rises with increasing height and that this rate of rise is stronger in the monsoon than in the hot weather months.

A method originally devised by Mr. Field of sending up, by means of balloons, recording instruments up to a height and then bringing them down by allowing hydrogen gas in the balloon to escape was further developed, and a new instrument for the measurement of temperature and humidity up to a height of 1½ kms. was designed for use with a balloon of this type. A slow burning fuse with reliability of action was devised for use with such balloons and also for releasing tails from pilot balloons after they have cleared possible entanglements. A simple and comparatively inexpensive instrument for locating the height of any particular upper air temperature aloft was designed for use with pilot balloons.

Colaba and Alibag.—In view of the transfer of the headquarters of the department from Simla to Poona, it was decided in consultation with the Bombay Government, the Bombay Chamber of Commerce and the Port Trust that the Bombay Daily Weather Report should cease to be published from May 1928, but that Colaba Observatory should issue a roneoed weather summary at about one o'clock every day to the local subscribers of the Indian Daily Weather Report.

Two experimental investigations, one on the measurement of earth currents and the other on the determination of atmospheric potential gradient with a Benndorff self-recording electrometer, have been in progress during the year at Bombay. A careful study is also being made there of the microseisms which are believed to be due to sea waves and appear in favourable circumstances to furnish early indications of the existence of disturbed weather out at sea.

The manuscript of the Observatory Volume for 1923 was sent to the press during the year. Good progress has also been made in the preparation of the 1924-25 volumes and they also will shortly be ready for the press. Besides the other routine duties of the observatory, about 45 chronometers were rated and issued, and 1,039 weather logs from ships were collected. Wireless time-signals broadcasted by Nauen, Bordeaux and Calcutta were received regularly throughout the year. The reception of time-signals relayed from Greenwich and broadcasted from Rugby commenced from the 18th January this year.

Calcutta, Alipore.—In addition to the ordinary routine duties of storm and heavy rainfall warning and time work, the Alipore Observatory has the important duties of supplying all Indian observatories with instruments and stores, keeping a stock of tested instruments and supervising third class observatories in northeast India. The Observatory made some preliminary arrangements in connection with the organisation of the special study of nor'westers. A new astronomical clock by Kullberg, for use in connection with the issue of time-signals, was installed in the constant temperature room in the observatory in November 1927.

The storm and flood-warning work of this observatory has been described in an earlier section of this report.

Madras.—The most important work, *viz.*, the supply of time by time-ball signal to local shipping, and by telegraphic signal throughout the Indian telegraph system and to the whole country generally, was carried out satisfactorily. The distribution of time over the country generally is made from the Madras Observatory by a signal transmitted daily at 16 hrs. I. S. T. over the Indian telegraph system ; considerable errors are inevitably introduced into the signal at stations where re-transmission is effected by hand. With a view to make the 4 p. m. telegraphic signals more useful to the telegraph offices and to the public, and also to conform as much as possible to the systems adopted in wireless time-signals, certain modifications in the method of sending signals are under consideration. Wireless time-signals from Calcutta and several foreign broadcasting stations including Bordeaux, Nauen and Rugby (Greenwich) are recorded regularly for comparison with the local time determination. Some preliminary observations have been made to redetermine the longitude of Madras by reference to the rhythmic signals from Bordeaux and Nauen. The Madras Daily Weather Report was published throughout the year.

Karachi.—Dr. B. N. Banerji, the meteorologist in charge, was deputed to Europe to study the recent developments in aeronautical meteorology, and Dr. S. K. Pramanik was posted there temporarily to carry on the duties of the office. Two sets of synoptic weather charts are daily prepared at Karachi and are occasionally supplemented by additional sets. These charts form the basis for the forecasts that are sent on request for R. A. F. aeroplane flights and also to aviators flying to or from the Persian Gulf area. Considerable work was involved in the initial meteorological arrangements for the Imperial Airship Route, already described in the first section of this report. In connection with these arrangements, a small office and quarters for three observers were built by the P. W. D. near the 260-foot temperature mast at the airship base.

Kodaikanal.—The collection and measurement of spectroheliograms from foreign observatories were continued during the year as a part of the programme of the International Astronomical Union. A report on the astronomical work of the observatory during the calendar year 1927 was published in February 1928.

One of the largest displacements of spectrum lines ever recorded in prominences was observed at Kodaikanal in an eruptive prominence on March 14, 1927. The prominence appeared to grow from almost nothing to a height of 300,000 kms. in 25 minutes and subside after reaching a maximum height of 630,000 kms. above the sun's surface.

At the request of the Director of the London Meteorological Office, Kodaikanal Observatory has agreed to take part next year, with a few other observatories in different parts of the world, in a programme of work designed to estimate the variations in the amount of ozone in the upper layers of the earth's atmosphere. This investigation is likely to throw light on the properties of the very high levels of the Indian atmosphere that may have some effect on weather conditions and wireless transmission.

The Assistant Director's post at Kodaikanal has been in abeyance since 1923, the year of retrenchment, and the full effect of its abolition was being felt in the diminished amount of research which could be accomplished. A fifty per cent. reduction in gazetted staff necessarily resulted in a relatively much greater reduction in research, for a considerable portion of the Director's

time was occupied in maintaining the efficiency of the ordinary routine work. In consideration of these facts, Government have now been pleased to restore the Assistant Director's post.

Quetta and Peshawar.—The R. A. F. Meteorologists at the local forecasting centres at the R. A. F. aerodromes at Quetta and Peshawar have continued to issue general accounts and forecasts of weather over the Delhi-Peshawar-Quetta-Karachi air routes and detailed local forecasts and warnings, each for his own immediate neighbourhood. Special route forecasts were issued on about 150 occasions by Quetta and on about 250 occasions by Peshawar.

This Department supplies instruments for the use of the R. A. F. Meteorologists and meets the cost of a small clerical staff at each station. A scheme was submitted to Government for increased clerical staff and was sanctioned with effect from 1st April 1927.

Meteorological flights by aeroplane for the observation of dry bulb and wet bulb temperatures aloft were continued almost daily at Peshawar ; similar sets of observations, 114 in all, of upper air temperatures were made at Quetta between June, 1927 and March, 1928.

Other Observatories.—Of the purely meteorological observatories whose records are scrutinized by this Department, 220 were maintained directly and 47 were non-departmental. Some of the departmental observatories are situated as far afield as Tehran, Kashgar, Aden and Seychelles. The departmental observatories consisted this year of 5 of the first class, 2 of the second class, 179 of the third class, 8 of the fourth class and 26 of the fifth class, according to the classification given in the report for 1918-19. The maintenance of these observatories, the supply to them of tested instruments, and the careful scrutiny of their observations naturally entail much work of a routine character at Alipore and at headquarters. The accuracy of observations depends upon the continuance of good exposure and good condition of instruments at the observatories, and upon the correct method of reading the instruments by observers. Good exposure of instruments can only be ensured by personal inspection by trained officers and the accuracy of observations can be estimated to a certain extent at headquarters from the number of mistakes detected in the data sent for the Indian Daily Weather Report. The stations of great reliability in which no mistake or at most one has been detected, numbered 19 and the number of stations at which more than 50 mistakes were made was 3. The average number of mistakes during the year at the remaining stations was 9.

Inspection of Observatories.—One of the essentials for continued accuracy of meteorological observations is the frequent inspection of observatories. During 1927-28, 70 observatories were inspected by Meteorologists and others. The Director-General visited the principal observatories at Bombay, Alipore, Agra, Madras, Karachi, Quetta and Peshawar. One pilot-balloon sub-station, Diamond Harbour, was inspected during the year.

Rainfall Registration.

20. The registration of rainfall has always been carried out under the control of Provincial Authorities. In 1889 a uniform system was introduced by the Government of India and the Director-General of Observatories was made the consulting officer in connection with this work. His advice is sought regarding the starting of new raingauge stations, and he receives annual reports upon the efficiency of the work from the local controlling officers who are in most of the provinces the Directors of Agriculture or of Land Records.

The following table based on reports for 1927-28 shows the number of provincial raingauges and the raingauges in the Indian States at the end of the year and number of inspections of these during the year, with corresponding figures for the preceding year :—

No.	Province.	No. of raingauges at the end of		No. of inspections.			Remarks.
		1927-28.	1926-27.	1927-28.	1926-27.	Change.	
1	Burma	214	224	229	224	+5	Generally satisfactory.
2	Assam	124	121	134	142	—8	Districts well-equipped.
3	Bengal	231	228	215	224	—9	Method of recording good.
4	Bihar and Orissa ..	297	297	274	268	+6	Generally well-maintained.
5	United Provinces ..	269	268	243	234	+9	Satisfactory.
6	Punjab	151	151	141	123	+18	Generally good.
7	North-West Frontier Province.	28	27	26	23	+3	In good order.
8	Baluchistan ..	81	81	20	26	—6	Railway Department stations not inspected.
9	Bombay	276	304	243	256	—13	Upkeep of rain-gauges specially attended to by Director of Agriculture.
9 (*a*)	Western India States	24	?	26	?	?	Transferred from Bombay Presidency.
9 (*b*)	Baroda	9	?	?	?	?	Defects of esposure to be remedied next year.
10	Rajputana ..	318	?	280	?	?	Generally good.
11	Central India ..	173	?	147	?	?	Good.
12	Jammu and Kashmir	33	33	24	26	—2	
13	Central Provinces ..	115	115	363	351	+12	Recording satisfactorily.
13(*a*)	Berar	42	41	84	101	—17	
14	Hyderabad ..	12	12	12	12	0	In proper condition.
15	Mysore	230	225	208	214	—6	
16	Coorg	9	9	7	7	0	
17	Madras	493	493	481	449	+32	Generally satisfactory.
	Total ..	3,135	..	..	..	..	

Heavy Rainfall Reports.—Heavy rainfall is occasionally so very local that small areas can have as much as 10″ without the Daily Report conveying the least suggestion of the heavy inundation. In order that such useful data might be promptly available for the Daily Weather Report it was arranged in 1921, with the approval of the Government of India that reports of 5″ or more of rainfall should be telegraphed to the forecasting centres from raingauge stations under the control of officers in charge of provincial rainfall organisation in India. The number of such telegrams received during 1927-28 was 170 as compared with 190 in the previous year.

Snowfall Registration.—Information as to the amount of distribution and time of occurrence of snowfall in the Himalayan and Afghan mountain areas was on the whole tolerably complete, and the thanks of the Department are due to the various officers who collected and forwarded the reports.

SUPPLY OF INFORMATION, PUBLICATIONS AND LIBRARY.

21. The ordinary channels for the supply of information to the public are the routine publications. From time to time, however, special information is also supplied to the Meteorological Departments of England, Australia and Egypt. Climatological and other meteorological data, at times involving special calculations, are also provided for sanitary and other officers of Government as well as the private firms who are willing to pay for the service. It may also be mentioned that the seismic data collected at Simla, Calcutta, Bombay and Kodaikanal are sent to the Seismological Committee of the British Association.

The routine publications of the Department are shown at length in the Administration Report for 1922-23.

The Daily Weather Telegram was despatched to subscribers daily about noon, and the weekly rainfall summary was supplied to the *Gazette of India.*

The Weekly Weather Report, containing matter similar to the Weekly Summary printed in the *Gazette of India,* was published by this Department during the monsoon period, and supplied to about 37 subscribers and also to the Press.

The number of institutions, etc., on the distribution lists of this Department was 335 at the end of the year.

Research Publications.—The following publications were issued during the year :—

1. *Scientific Note, Volume I, No. 1.*—" A comparison of upper and gradient winds at Agra and Bangalore " by Md. Ishaque.

2. *Scientific Note, Volume I, No. 2.*—" An analysis of the Madras hourly rainfall records for the years 1865 to 1875 and 1901 to 1917 " by V. Doraiswamy Aiyar.

3. *Indian Meteorological Memoirs, Volume XXIV, Part XI.*—" Sky illumination at Sunrise and Sunset ", by K. R. Ramanathan.

Library.—Books, periodicals and pamphlets either purchased or received as presentation copies in the department's libraries at Simla and Calcutta during the year numbered 746. The total number of books and pamphlets which have been catalogued and classified in the library at the headquarters was 9,866 on the 31st March, 1928.

CONCLUDING REMARKS.

22. The Meteorological Department owes a large part of its usefulness to the sympathetic assistance it receives from other departments. Civil Surgeons and other officers of Government Departments, as honorary superintendents of

observatories and in other capacities, help the meteorological work ; the Posts and Telegraphs Department assist in the rapid transmission of meteorological information ; at the same time they allow their employees to act as observers. Weekly telegrams are received from April to October from the Director, Royal Alfred Observatory, Mauritius and from the departmental observatories at Zanzibar and Seychelles. These telegrams give valuable information of the weather conditions in the Indian Ocean, and the department is indebted to the officers indicated for the punctual transmission of the information. Thanks are further due to the Director of Royal Alfred Observatory for his courtesy in placing the meteorological data of that observatory at our disposal.

The department is greatly indebted for important information on meteorological conditions prevailing before and during the southwest monsoon to the Controller, Physical Department, Cairo ; the Directors of the observatories at Buenos Ayres, Santiago and Batavia ; the Astronomer Royal, Cape Town ; Director L'Observatoire Physique Central, Leningrad ; the Secretary, Friends' Industrial Mission, Banani Pemba, Zanzibar ; the Principal Medical Officer, Tanganyika Territory, Dar-es-Salaam ; the Commonwealth Meteorologist, Melbourne ; Director of Agriculture, Salisbury, Rhodesia ; Chief of the Weather Bureau, Washington, and to the various officers around the Indian frontiers who have collected and supplied valuable snowfall information.

The thanks of the Department are due to the Superintendent of Colombo Observatory for the very useful help he has rendered from time to time in connection with storm warning work. The Department is also grateful to the Director, Koninklijk Magnetisch en Meteorologisch Observatorium, Batavia, Java, who has arranged for daily weather telegrams to be sent from Sabang in Sumatra during the cyclone months April, May and October to December. The Department would also like to take this opportunity of thanking the Press Photo Bureau, Triplicane, Madras, the Agent, Bombay Baroda and Central India Railway, Bombay, and the Manager, Jamnagar Photo Company, Jamnagar, for their kind permission to reproduce in the present issue of the Administration Report the photographs showing damage caused by the Gujarat floods and the Nellore storm last year.

C. W. B. NORMAND,
Director-General of Observatories.

POONA :
The 25th August 1928.

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Report on the Administration of the Meteorological Department of the Government of India in 1928-29.

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Chief Features of the Year.

The transfer of the headquarters office from Simla to Poona in batches was completed by the middle of June. The opening ceremony of the new building was performed by His Excellency Sir Leslie Wilson, Governor of Bombay, on the 20th July 1928 in the presence of the Hon'ble Sir Cecil McWatters, then acting Member of the Governor-General's Executive Council, who reviewed the work of the Department from its commencement up to the present day. He emphasised the need for further research on the relation between Upper Air and Surface Meteorology. His Excellency in welcoming the Meteorological Headquarters to Poona referred to the services rendered by meteorology to shipping, aviation and other interests and expressed the hope that the department in its new headquarters would be able to do something in a new branch of research, namely Agricultural Meteorology, besides carrying on other useful work.

2. The first half of the year at Poona was spent in heavy administrative work connected with the transfer of the office from Simla to Poona and the work of re-organisation at the new centre. In spite of the general disorganisation of the headquarters office, considerable attention was paid to researches in both theoretical and practical Meteorology and allied subjects. A number of investigations were taken up by officers and assistants of the department and also by a few science graduates who worked for short periods as voluntary research workers in the Poona office.

3. A spacious hall has been set apart in the new building for use as library where a large number of books and periodicals have already been suitably arranged and adequate facilities have been provided for use of the hall as a study. Fair progress was made in organising a first class observatory and fitting up a laboratory and workshop at the new office.

4. In order to meet the requirements of the London-Karachi Air Mail Service, arrangements were completed towards the end of the year for issuing, through the Karachi civil wireless station, synoptic weather broadcasts on short wave at regular intervals, also for supplying weather reports by wireless to aeroplanes in flight and for receiving synoptic broadcasts from Baghdad.

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5. Besides these preparations at Karachi, the activity of the Department was largely directed to the formulation of schemes for meteorological organisation in connection with the future development of air service in India and its neighbourhood. The proposed service will consist of three distinct sections (1) Karachi-Delhi, (2) Delhi-Calcutta and (3) Calcutta-Rangoon with ultimate extension to Victoria Point. The Department will thus eventually be responsible for meteorological services to an air route extending from Basra in the west to Victoria Point in the east and will in this respect occupy a unique position such as very few meteorological organisations in the world have had to undertake. In connection with the Karachi-Delhi and Delhi-Calcutta sections of the air service which are expected to open towards the end of 1929 and 1930 respectively, a scheme for the provision of meteorological facilities was prepared and submitted to Government for sanction. The scheme comprises the location of a forecasting centre at Delhi in charge of a Meteorologist and the fitting up of complete sets of self-recording instruments at six aerodromes along the route besides other details of minor character. In February 1929 Dr. S. C. Roy, Meteorologist, was deputed to inspect the aerodromes along the route from Karachi to Calcutta and report on the possibility of meteorological developments at these places.

6. The International Meteorological Committee, which is the permanent executive body of the International Meteorological Organisation, has decided to form a permanent Secretariat under the direction of the President, which will temporarily be located at either De Bilt or Utrecht in Holland. The Secretariat will be responsible for the organisation of meetings of the Committee and of Commissions and for reports of these meetings ; it will also serve as a centre for recording information concerning the meteorological services of the whole world, and will help, as much as possible, the President of the Committee and the Presidents of the Commissions in the performance of their international duties. The annual contributions to be asked from different countries for the upkeep of the Secretariat were fixed at 4,000 gold francs from large, 2,000 from medium sized and 1,000 from small countries. The Government of India was pleased to sanction the payment of 4,000 gold francs annually as India's contribution to the International Meteorological Secretariat.

The Opening Ceremony.

7. As stated in the previous section the opening ceremony of the new headquarters building of the India Meteorological Department at Poona was performed by His Excellency the Governor of Bombay on the 20th July, 1928. A large body of Government officials and other distinguished gentlemen were present at the ceremony. The Hon'ble Sir Cecil McWatters (then Mr. McWatters) on behalf of the Government of India, before requesting His Excellency to declare the building open, said :—

> " May I, in the first place, on behalf of the Government of India, express my thanks to Your Excellency for having so kindly consented to perform this opening ceremony of the new headquarters of the Meteorological Department ? I recognize the heavy calls upon Your Excellency's time and attention and it is therefore a matter of great gratification that Your Excellency and Lady Wilson have been able to honour us with your presence to-day. The occasion is a memorable one for the Meteorological Department. Ever since the

foundations of Indian Meteorology were laid by Mr. Henry Blanford 53 years ago, as opposed to the fragmentary studies of weather that had been made before that date in various provincial offices, the Department has had no permanent official home and to-day marks for ever the relinquishment of a series of temporary headquarters which from their unsuitability have undoubtedly retarded progress.

"The Department is one which suffered a good deal from the inevitable retrenchment after the War, but the last few years have happily been years of expansion and it is certainly true that the practical activities of the Department are now more widely recognized and appreciated than ever before. In their late Simla headquarters, it was possible for the Department to deal with questions of surface meteorology by consideration of ground-level data collected in India and elsewhere, and Mr. Henry Blanford, Sir John Eliot and Sir Gilbert Walker have done invaluable work on these and allied lines. Sir Gilbert Walker indeed in his search for factors which may help to predict the Indian monsoon, was led into studies of world-weather, which form the most complete discussion of the subject available at the present day. Also one very notable experimental enquiry in Simla led Dr. Simpson, now Director of the London Meteorological Office, to publish an explanation of the cause of electricity in thunderstorms in a memoir which has become a classic in meteorological literature.

"But we are now to add those great fields of fruitful enquiry which depend essentially on accurate physical measurements in the higher winds of the upper air. It is largely upon these features of which at present we have little knowledge, that surface weather is now believed to depend, and India in undertaking this work is in the good company of most civilized nations of the world, with a fair chance of becoming one of the leaders in the van. The pioneer of such upper air work in India was the late Director-General of the Department, Mr. J. H. Field. His earlier efforts were necessarily spasmodic and hampered by the location of the Department's headquarters in Simla. To the layman it is always a surprise that Simla, in spite of its height, is unsuitable as a centre of upper air work. This is so, because balloons carrying instruments land somewhere in the depth of the Himalayas or in Tibet and are never recovered. But it was under Mr. Field's direction that the first serious and continuous effort was made by the institution of the Upper Air Observatory at Agra in 1914.

"I have emphasised the importance of this new development of upper air research because it is from this point of view that we attach perhaps the greatest importance to the removal of the headquarters of the Department from Simla to an adequate home in Poona in the main path of the monsoon. With our present increased scientific staff and with our improved budget, there is every reason to believe that within the next decade or two great progress will have been made in the understanding of the mechanism of Indian weather, and the Indian Budget may be no longer a "gamble in rain."

"But there are other advantages also which we expect to result from the transfer from Simla to Poona. One duty of headquarters is to warn ports and shipping on the west coast of India about storms or cyclones in the Arabian Sea, and we feel that our proximity to Bombay and the consequent possibility of maintaining close touch with shipping interests cannot but lead to greater efficiency in the storm-warning system. This new building, too, lies between the Colleges of Agriculture and Engineering; to both of these subjects the Meteorological Department is frequently called upon to apply the results of meteorological knowledge and we look forward to a healthy interplay of ideas between these institutions.

"The work of the Department covers many other forms of activity, which I can only touch on briefly to-day. The Observatories at Bombay, Calcutta and Madras supply correct time to the shipping at those ports. At Alibag there"

is a magnetic observatory of the first order and at Kodaikanala Solar Physics Observatory which maintains a close daily spectroscopic watch of the Sun's variations. From Poona we can keep in closer touch with the activities of both these observatories than we can from Simla. There is also a system of warning for heavy rainfall and the Department has much to do with the supply of weather reports to aircraft, both Civil and Military. In this direction their duties are likely to become vastly more important in the future. The various exhibits which visitors are cordially requested to inspect at the end of the ceremony are intended to illustrate some of these various lines of work for which the Department is responsible.

"I should like to refer to one other matter. It has been the policy of Government for some years past to recruit young Indian scientists for the Weather Department as far as possible. This policy has been consistently followed and we have now only two British officers left, the present Director-General, Dr. Normand, who is worthily carrying on the great traditions of his distinguished predecessors, and Dr. Royds, who is engaged on specialist Solar Physics work at Kodaikanal. The Indian gazetted staff numbers 25, all with excellent scientific qualifications, and forming a band of officers who in academic distinction will compare favourably with any other meteorological service in the world. We look to them with confidence to maintain the traditions of the Department. In meteorological literat re we read of the theories and practice of the Norwegian school or the Vienna school of Meteorologists. We look forward to the day when the Indian Service will be regarded throughout the world as having attained by right of research and of practical results the honourable title of the "Indian School of Meteorology."

"We are celebrating to-day the opening of the Department's new home in a building worthy of its record and of what we hope for its future. To the architects, Messrs. Stevens and Partners, who designed the building and supervised its construction and to the contractors, Messrs. Pallonjee Eduljee, who have co-operated with the greatest good-will, I should like to take this opportunity of expressing our appreciation of their services. I will now ask Your Excellency to be so good as to unveil the two tablets in the Entrance Hall and to wish success to the Department in its new home."

8. In declaring the building open, His Excellency said :—

"The establishment in Poona of the first permanent headquarters of the Meteorological Department of the Government of India is an event of considerable importance, and I should like to assure you, on behalf of my Government and myself, that we very heartily welcome the Department here and to request you, Mr. McWatters, to convey to the Government of India this expression of our sentiments. We are familiar in India with the value of the work done by this Department in forecasting and recording the progress of the monsoon, and last year we had in this Presidency a striking example of the importance of its weather warnings, in Gujarat and the neighbouring States, which enabled measures to be taken to guard against damage by heavy rains and floods. The reports which I have seen, from local officers in the districts affected, indicate that, although the floods were sudden and widespread, the warnings of the Department made it possible to take, in several places, steps which, although they could not prevent serious damage, mitigated to some extent the disastrous effects of that widespread calamity. The loss of the two passenger ships not far from Bombay last year proved how important it is to obtain early warning of the state of he weather on our coasts, and we may hope that the establishment of this office here will make it possible in the future to give longer notice of the movements of cyclones, which do so much damage in the Arabian Sea. Mariners on the other side of India have, I believe, a weather prophet of their own at Calcutta, and I have no doubt that the work of this office in Poona will give our people on the West Coast a feeling of greater security.

"I think I am right in saying that great strides have been made of recent years in Europe in one branch of your activities, namely, the forecasting of weather in connection with the rapid development of aviation there. The forecasts which appear every day in the Press are not only more detailed, but, so far as my observation goes, a great deal more accurate than they used to be. The needs of India in this connection are not yet so prominent, but every year brings us nearer the flying age in this country too, and I am confident that the demands on this office for accurate data and reliable forecasts will rapidly increase; consequently I do not think that the important step which the Government of India has taken in setting up permanent headquarters for the Department has come a moment too soon.

"The fact that the site which has been chosen for the Meteorological Office is so near our own College of Agriculture is, I trust, a good omen for the future. Other branches of the work done here may interest large sections of the public, but the connection between meteorology and agricultural is one of the deepest interest for all the people of India. Indeed I believe that the Meteorological Department itself had a sort of agriculture origin, for I am told that it was originally started on the recommendation of a Famine Commission, with the object of keeping the administration informed regarding the progress of the monsoon in all parts of India, and, if possible, of forecasting the monsoon rainfall. There is, to my mind, room for very close co-operation between the Meteorological Office and the Agricultural Department. To take a very simple example, it is clear that five inches of rain, well distributed over a whole month, is of much greater value to the crops than five inches all falling on one or two days in the month, and yet they would both appear in the rainfall statistics as five inches. There appears, therefore, to be room for research into the relation of rainfall to crops, the results of which might be of great practical value in an agricultural country such as this.

"I am fully aware of the arduous nature of meteorological research, and it may be that some expansion of the Department would be required to deal with a new branch of research, but it is possible that Dr. Normand may be able to do something in this direction during his term of office, and I can assure him that we shall be very willing for our Agricultural Department, and our Agricultural College, to co-operate with him in any direction in which their assistance may be of value.

"We may well congratulate ourselves on this latest addition to the architectural features of Poona, and upon the fact that the architects, Messrs. Stevens and Partners, and the contractors, Messrs. Pallonjee Eduljee, are both Bombay firms. The foundations of the building were begun in December 1926, and the result that has been so expeditiously achieved reflects the greatest credit on those responsible for designing and executing the work.

"I have had great pleasure in unveiling the tablets in the Entrance Halls and I am sure you will join me in thanking Mr. McWatters for coming from Simla in order to take part in this ceremony, and in wishing all success and prosperity to Dr. Normand and his staff in their new surroundings."

9. Following the opening ceremony there was an exhibition of meteorological instruments, weather maps, charts etc., and work of geophysical and astronomical interest illustrative of the varied activities of this department. The exhibition was thrown open to the public on the following day and proved a great attraction, the number of visitors, at a conservative estimate, exceeding 2,500. As several officers from sub-offices had been present at Headquarters for the opening ceremony, this was made an occasion for convening a conference of departmental officers in which matters of administrative and scientific interest were discussed. It has since been decided that a similar conference of officers shall be held once every year at Headquarters.

Storm Warning Organisation.

10. *The system of storm warning for ports and shipping.*—The warning of ports and shipping in the Arabian Sea against the approach of cyclonic storms or of bad weather was done from Poona, while Calcutta continued to issue similar warnings for the Bay of Bengal. At present the storm warning list consists of 37 ports on the west coast including three added during the year, and 28 ports on the Bay of Bengal. The station at Elephant Point was closed, while at the instance of the Presidency Port Officer, Madras, Bimlipatam was added to the list of ports under the "general" system. In addition to these regular ports, there are 8 river ports, 14 River Police Stations and 41 District Police Stations which have to be warned by Calcutta in connection with disturbed weather at the head of the Bay of Bengal. At the request of the Government of Bengal three Sub-Divisional Officers in the district of Backerganj were added to the list of River and District Police Stations. Although they do not hoist signals, they now receive warnings on occasions when "warning", "danger" or "great danger" signals are ordered at the river ports and Police Stations. Of the Bay ports 12 are provided with additional information regarding the particular areas in which weather is disturbed by a special system of 'locality signals'. Shipping at sea is also supplied with the latest weather information by means of wireless bulletins broadcast twice daily or more frequently whenever necessary. The radio stations at Bombay, Karachi and Aden serve the Arabian Sea area, whilst those at Calcutta, Rangoon and Madras serve the Bay of Bengal area. The radio station at Matara (Ceylon) serves both areas. The total number of warning messages issued was 8,176.

11. *Warning to ports and shipping in the Bay of Bengal.*—During the year warnings were issued for 32 periods of disturbed weather. Of these 7 developed into storms of slight to moderate intensity two of which are briefly described below.

A shallow depression appeared over the north Bay of Bengal on the morning of the 5th June 1928 in the neighbourhood of Lat. 18° 30′ N., Long. 89° E. Moving in a northeasterly direction, the depression intensified gradually and by the evening of the 6th developed into a storm with its centre near Lat. 20° N., Long. 90° 30′ E. By 11 hours on the 7th June the storm moved near Cox's Bazar and began to weaken. It caused strong winds with squally weather as far south as the Andamans and was responsible for heavy rain on the north Arakan and Chittagong coasts.

The storm of the third week of October, which crossed the coast near Madras on the 21st evening, although of slight intensity, was remarkable for the heavy rain and floods caused by it in the Vizagapatam and Godavari Districts. The floods resulted in very serious breaches in the railways and roads and a complete breakdown of telegraphic communication and were responsible for considerable damage to property and loss of some lives.

12. Reports on the working of the warning system were received by Meteorologist, Calcutta from 25 Port Officers on his warning list. Most of these officers expressed their satisfaction with the warnings. Among several

appreciative opinions may be mentioned two from the Harbour Master, Calcutta :—

> " Your telegram of the 18th April—' Thunder-squalls likely this evening south Bengal '—was of very great assistance to us in determining the movements of vessels during the late afternoon and evening of that day ".
>
> " The warnings in reference to local signals for nor 'westers are of very great advantage to my department."

13. *Warnings to ports and shipping in the Arabian Sea.*—The west coast ports are warned not only for storms but also for squally weather, especially at the onset of the monsoon. During the year warnings were issued on 32 occasions in connection with depressions, squally weather or winter disturbances. No storm formed in the Arabian Sea during the year. For the Arabian Sea area, reports on the working of the marine warning system were received from 18 officers on the warning lists. The Port Officers at Bombay, Cochin, Calicut, Tellicherry and Mangalore in their reports stated that the warnings were timely and satisfactory in every respect and that no change in the present system was necessary.

14. *Ships' Observations.*—As usual the department continued to render the utilitarian services of issuing warnings for storms at sea. The chief sources of marine data which are at present available for use by the department are wireless weather messages from ships in Indian waters. The wireless weather messages from ships are meant primarily to supplement the observations from coast stations. In the absence of a large number of observations from sea areas during disturbed weather it is very difficult to draw correct conclusions regarding the formation, position, movement and intensity of storms. This difficulty is even now very keenly felt by the department for lack of an adequate number of ships' weather messages, especially in connection with the storms in the Arabian Sea, as inferences have, in the circumstances, to be drawn mainly from information from a very open net work of land observatories along the west coast.

The total number of ships' messages from the Bay and the Arabian Sea this year was 4,342 (from the Bay 2,604 and from the Arabian Sea 1,738) as against 4,835 in 1927-28. This number compares rather unfavourably with the previous year's. The department, while gratefully acknowledging the valuable assistance rendered by the commanders of ships who took part in this voluntary service of marine observers, feels that further co-operation is possible and takes the opportunity of emphasising the importance of a far greater response to requests from storm warning centres for ships' messages in the interest of mariners. It would be most helpful if the co-operating captains could try to induce others to take a share in this voluntary work of giving weather information from the sea. It should be constantly kept in mind that no matter how common-place a set of observations may appear by itself, it is of immense value during storm seasons, when it is considered along with the other observations plotted on a weather chart. There is also a great future for synoptic meteorology at sea ; but it will not be possible to make full and early use of this great aid to navigation and safety of life at sea without more extensive co-operation between the sailor and the meteorologist. The need of further co-operation of ships in all parts of the Arabian Sea is therefore

again urged and the Port Officers on the west coast area are especially invited to assist this department in propaganda amongst ships' captains.

Special mention should be made of the following steamers from each of which 40 weather messages or more were received during the year :—

1. Barpeta	244	13. Morvada	55
2. Beme	129	14. Maharaja	52
3. Shahjehan	115	15. Garbeta	52
4. Vita	111	16. Elephanta	51
5. Cocanada	103	17. Bahadur	50
6. Aungban	64	18. Egra	46
7. Juna	64	19. Aronda	42
8. Masimpur	64	20. Bovenkirk	41
9. Singu	63	21. Ethiopia	41
10. Badarpur	62	22. Bankura	40
11. Angora	61	23. Rajula	40
12. Erinpura	57		

The department heartily congratulates the Commander of the B. I. S. N. Co's. steamer " Barpeta " which sent the largest number of wireless weather messages for the last two years in succession.

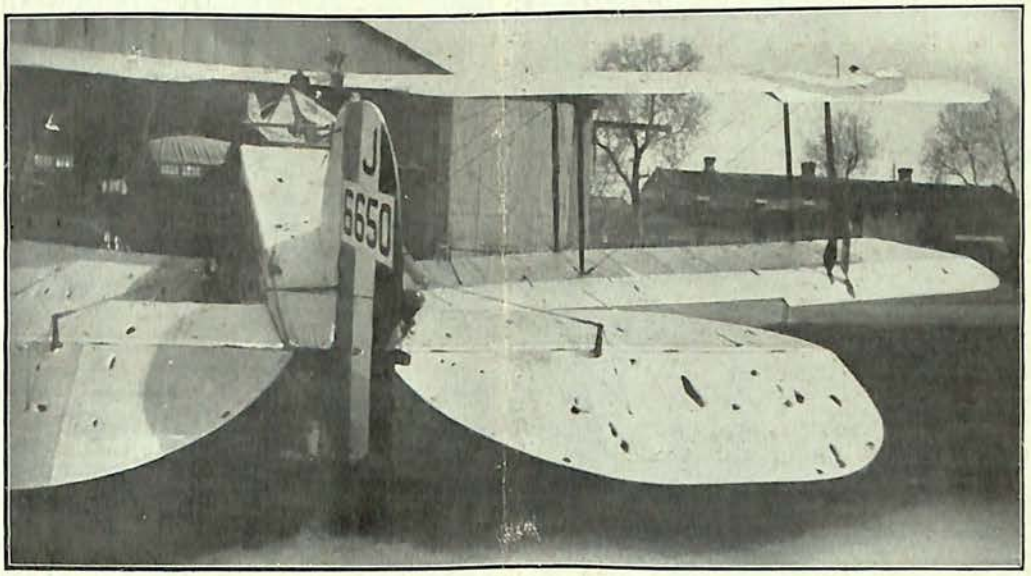
15. An important source of marine data, apart from ships' wireless messages, is the log extracts collected mainly in Calcutta and Bombay. The observers of the Time-Ball and Tidal Observatory of the Rangoon Port Commissioners supplement these data from extracts collected at Rangoon. Occasionally, in special cases, logs of steamers experiencing disturbed weather are collected at Madras ; and the Colombo Port authorities also render similar help whenever requested. A total of over 4,000 logs were recorded by the end of the year as against about 3,000 collected during the previous year.

16. The policy of lending meteorological instruments to ships is being pursued slowly but steadily. During the year under review two more ships were added to the list of those supplied with instruments on loan, thus bringing their total number to 14. It is noted with satisfaction that the captains of all these 14 steamers regularly forwarded their weather logs to this department. The department also gratefully acknowledges the co-operation of shipping firms in the matter of collection of weather information from the Indian Seas both during fair and disturbed weather ; special mention should, in this connection, be made of the willing help rendered from time to time by Captain E. Trott, Marine Superintendent of the Asiatic Steam Navigation Co., Captain Jas. MacLean, Marine Superintendent of the British India Steam Navigation Co., Captain Whish, Port Officer, Bombay and Commander Norcock, Deputy Conservator of the Port of Calcutta.

Inland Weather Warnings.

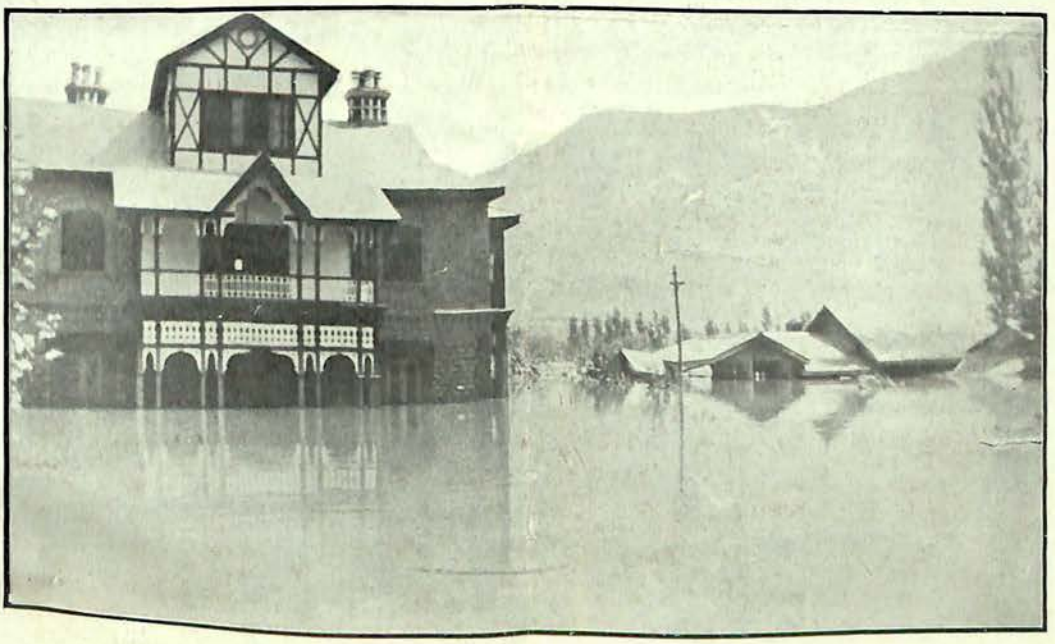
17. Inland weather warnings for heavy rain on land were issued during the year by both Poona and Calcutta. Most of the officers on the warning lists are district officers and officers of the irrigation, railway and other departments. The total number at the end of the year was 207, the same as in the previous year. In addition, there were 26 officers of the Telegraph Department who generally required warnings for strong winds.

HAILSTORM AT PESHAWAR, 28TH MARCH 1928.



AEROPLANE DAMAGED BY HAILSTONES.

KASHMIR FLOODS, SEPTEMBER 1928.



STREET UNDER WATER AT SRINAGAR.

Photo engraved and printed at the Govt. Photozinco. Office, Poona, 1929.

18. The number of special inland forecasts and warning messages issued by the Department during the year was 2,942. In addition 852 telegrams of actual heavy rainfall were sent by local meteorological observers direct to various officers.

19. At the end of the year 117 reports on the working of this system were received from recipients of these warnings. Most of them stated that the warnings were satisfactory, while a few offered suggestions or minor criticisms which have received consideration.

On the whole, a comparison of the inland warnings with the actual subsequent rainfall and the tracks of storms across the country shows that most of the warnings issued were timely and proved useful to the recipients.

A special circular letter was issued by the Meteorologist, Calcutta, to officers warned in connection with the storm which affected the Madras coast during the third week of October. The following are some of the opinions expressed by the local officers:—

Collector of East Godavari District, Cocanada.	"I have received intimation from the meteorological authorities on the 21st morning (Sunday) that 48 hours heavy rain was to be expected. The expectations were fulfilled, and there was heavy rain on Sunday and Monday last."
District Traffic Superintendent, Guntakal.	"The advice regarding heavy rain on the Coromandel coast was received in this office on 20th October 1928 and necessary precautionary orders were at once issued to stations. There was heavy rain between Nandyal and Bezwada but no damage or loss of life occurred. The advice was timely and useful."
Executive Engineer, G. H. Division, Dowlaishwaram.	"No damage has been caused to any works in any jurisdiction. I am of opinion that the warning in question was of considerable use to all concerned."

Several letters of appreciation were also received in connection with warnings issued from Poona. The following are a few instances:—

(1) In a letter dated the 17th December 1928, the Political Agent, Banas Kantha, Palanpur, wrote:—

"The information supplied proved correct in almost all cases during last monsoon".

(2) The Chief Engineer in Sind in one of his letters wrote:—

"I am very pleased to note the care and regularity with which the warnings are issued by the Meteorological Department,"

(3) The following is an extract from the letter, dated the 7th January 1929 from the Executive Engineer, Nasrat Canals Division:—

"..... they (warning telegrams) proved to be very useful. The canal officers were thus kept on their guard."

20. Requests were also received at the headquarters on many occasions from Government officials and private firms for the issue of special weather reports and forecasts and were promptly complied with. A letter of apprecia-

tion from Major H. L. Ovans of the Army Headquarters, India, may be quoted here :—

> " I am directed by the Adjutant General to write and thank you for the very accurate weather forecast for the forenoon on 4th June (Monday), which your staff at Poona telegraphed on Sunday night. Owing to the cloudy weather early on 4th June it was not at all easy to decide whether the rain was likely to hold off during parade hours, but the forecast helped to confirm the justified decision not to cancel the parade."

21. As mentioned in the last Administration Report the warnings for heavy rain are now included in the Daily Weather Telegram, the text of which is published in most of the important newspapers.

It is suggested that officers and others whose duties require them to keep a close watch on the weather would be better able to do this if they subscribe to the Daily Weather Telegram issued from Poona which only costs Rs. 10 per month.

Offices and Observatories.

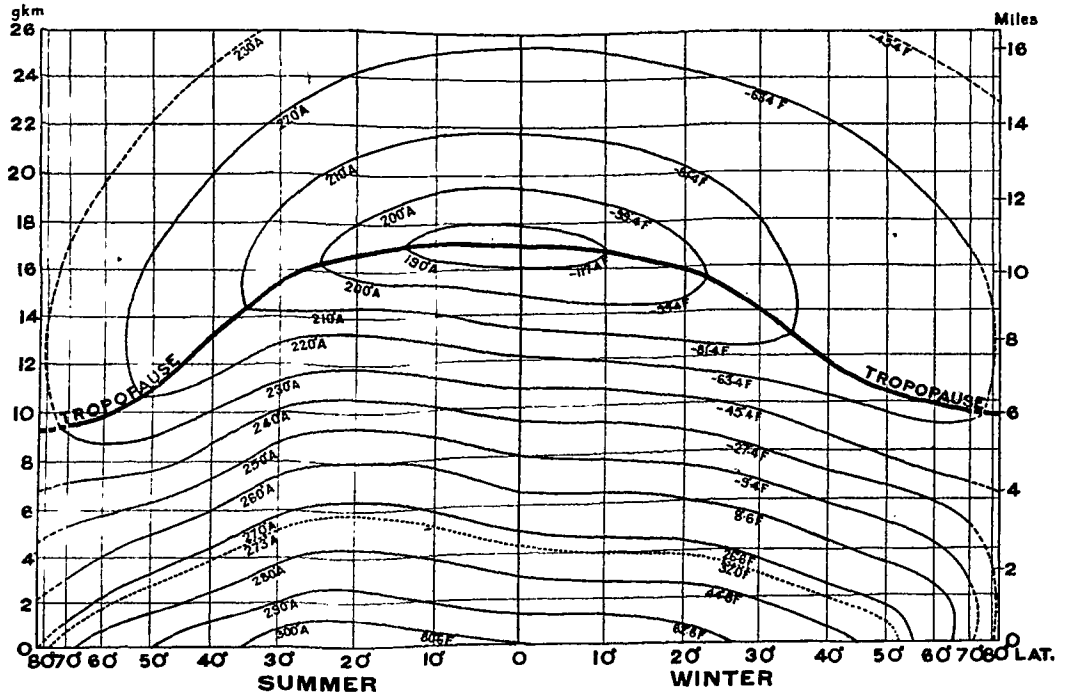
22. *Headquarters Office, Poona.*—The re-organisation of the work at headquarters by dividing the office into seven sections was mentioned in the last year's report. It is desired now to give a brief outline of the activities of the respective sections.

(1) *General Section (Officer-in-Charge—Dr. S. N. Sen).*—This section is responsible for administration of headquarters and sub-offices, and deals with budget and accounts, establishments, general registry, all technical questions involving change of policy or fresh expenditure and the co-ordination of technical work of the Department. During the year pressure of work at headquarters, and in the General Section in particular, was very heavy on account of the additional duties arising out of the construction of the new office buildings at Poona and the transfer of the headquarters office. In fact, so much time was taken up by these abnormal items of work that the serious difficulties could only be overcome through overtime work and the ungrudging co-operation of all the officers and ministerial staff at headquarters and also by the sanction of some extra temporary clerks by Government. This section also had to deal with increased correspondence with foreign Meteorological centres on international matters and had to formulate a number of new schemes, the most important of them being in connection with the preparations for civil aviation in India.

(2) *Weather Section (Officer-in-Charge—Dr. S. C. Roy).*—Details of the work done by this section in connection with the issue of warnings for storms and heavy rain and of special weather forecasts when called for have already been given on pages 6—9. In addition, the weather section is responsible for the issue of a daily telegraphic summary of the general weather situation over the country with a forecast for the next twenty-four hours and the publication of Daily, Weekly and Monthly Weather Reports and the descriptive chapter of the part relating to weather in the Annual Summary.

During the year 71 weather forecasts for aviation purposes were issued. Questions such as revision of weather message codes etc. to suit aviation purposes were also considered by the section.

UPPER AIR TEMPERATURES OVER THE NORTHERN HEMISPHERE.



The above diagram which has been prepared from data collected from all parts of the world shows the distribution of temperature in the atmosphere up to a height of 16 miles over the northern hemisphere in summer and winter. The thick line marked "tropopause" separates the *troposphere* (the region where the air temperature generally falls with height) from the *stratosphere* (the region where the air temperature is either uniform or increases with height). It can be shown from physical principles that convection can take place only within the troposphere.

The following features are noteworthy:—

(1) At the surface of the earth, the atmosphere is hottest near the equator and coldest near the poles, but up above, this contrast is gradually lost until at a height of 10 miles we actually meet with *colder* air over the equator than over the poles.

(2) The coldest air over the earth, at a temperature of about—120° F, occurs over the equator at a height of about 11 miles in the form of an anchor ring.

(3) Over the tropics, the temperature in the stratosphere increases with height.

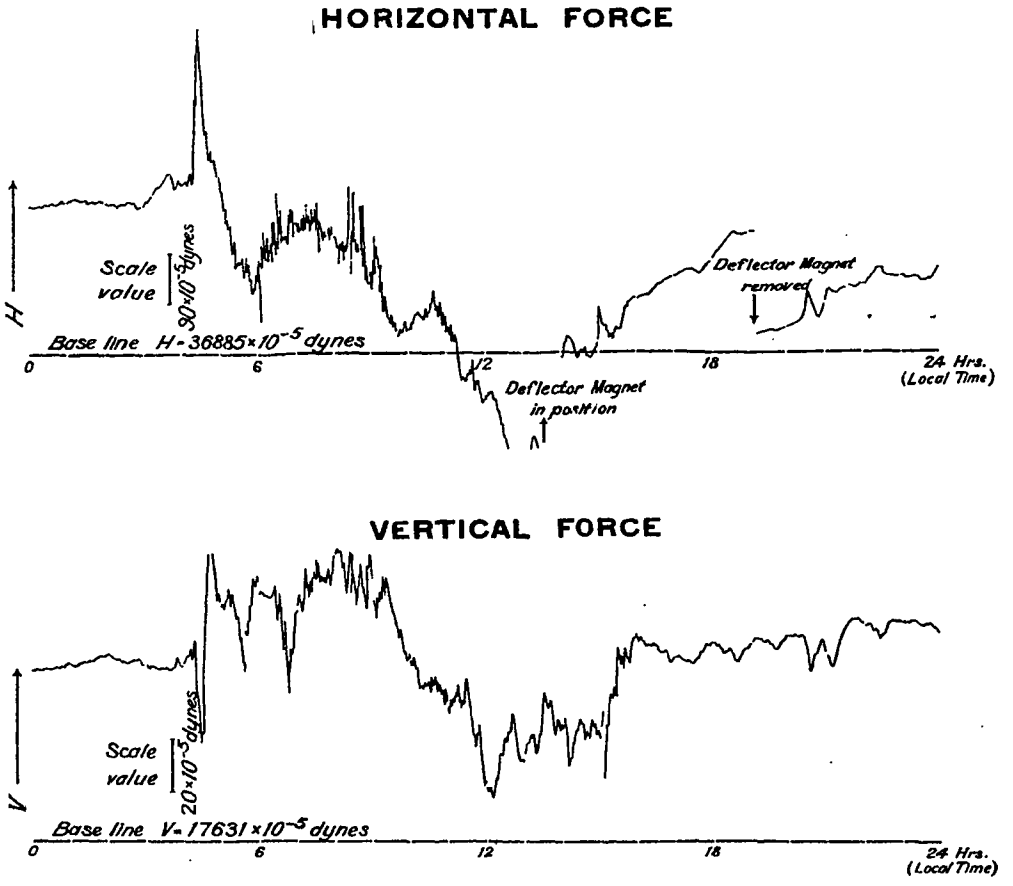
(4) The ring of lowest temperature at the tropopause is displaced further northwards in the summer than in the winter.

Results obtained at Agra have been of great help in settling important points in the construction of the above diagram.

The scale for latitude is a sine scale, so that the distance between any two latitudes in the diagram is proportional to the area of the earth's surface enclosed between them.

MAGNETIC STORM 8TH. JULY 1928.

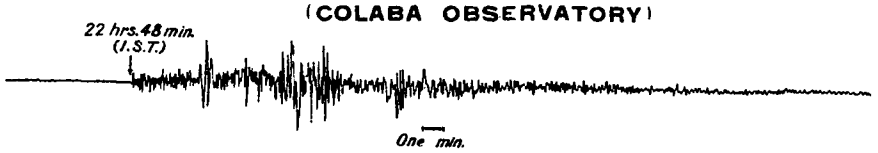
(ALIBAG OBSERVATORY)



SEISMOGRAM OF

AFGHAN EARTHQUAKE 1ST. FEB. 1929.

(COLABA OBSERVATORY)



The first two graphs depict the fluctuations of the horizontal and vertical components of the Earth's magnetic field during a magnetic storm which completely dislocated the telegraph traffic on the 8th. July 1928. This storm also caused brilliant auroral displays and is the severest on record at Alibag since May 1921. It was associated with a special group of sunspots past the sun's central meridian.

The last graph is the record of an earthquake shock which had its origin in Afghanistan. It was felt at Delhi, Lahore and several other places in the Punjab and the North-West Frontier Province and caused considerable damage in Turkisthan.

(3) *Observatories Section (Officer-in-Charge—Dr. K. J. Kabraji).*—This section is responsible for the efficient maintenance of all 3rd to 5th class observatories, except those that are in charge of the Meteorologist, Calcutta or the Meteorologist, Karachi. During the year, 67 observatories were inspected by Officers and Assistants sent out from Headquarters. The number of stations telegraphing visibility in the daily weather telegram increased from 74 to 125. The observatories of great reliability, where no mistake or at most one has been detected, number 24 and the number of stations at which more than 50 mistakes were made was 3. The average number of mistakes during the year at the remaining stations was 10. A brief account of the registration of rainfall carried out under the control of Provincial Authorities is given in a subsequent chapter of the report.

In addition to the duties mentioned above, the periodical supply of meteorological data and reports on meteorological conditions to various Government officers were continued.

(4) *Marine Section (Officer-in-Charge—Mr. S. Basu).*—The object of the section is to undertake special studies in marine meteorology, especially in connection with the formation, growth and subsequent movements of destructive storms and cyclones. The section will eventually be responsible for establishing closer contact and fuller co-operation with the shipping interests in the country than has been possible hitherto.

(5) *Instruments Section (Officer-in-Charge—Mr. J. M. Sil).*—The important routine duties of the section are as follows :—

(*a*) All questions relating to meteorological instruments which involve preparation of annual and supplementary indents on the London and Delhi Stores Departments ;

(*b*) specification, design, testing, calibration and repair of instruments ;

(*c*) maintenance of special instruments throughout India and examination of their records ;

(*d*) equipment and maintenance of workshop and laboratory at Poona.

(6) *Upper Air Section (Officer-in-Charge—Dr. K. R. Ramanathan).*—This section is responsible for upper air work at Poona and co-ordination of results of upper air observations throughout India. Sounding balloon work was begun at Poona in August 1928 and the first instrument was sent up on the 6th of that month. With the kind co-operation of the Government of Bombay and the neighbouring Indian States arrangements were made for the recovery of sounding balloon meteorographs through the Mamlatdars. Up to 31st March, 1929, 31 instruments were sent up and 15 were recovered ; of these 7 penetrated into the stratosphere. The first instrument that was recovered had reached a maximum height of about 12 miles ; the base of the stratosphere was seen from the record to be at a height of 10 miles with a temperature of—119° F., or 151°F. below the freezing point. In the stratosphere above the height of 10 miles, the temperature again increased to —87°F. at the top of the ascent.

As a first step towards the co-ordination of upper air observations, the publication, in fourteen parts, of data from 1st January 1928 collected by the department from ascents of pilot balloons, sounding balloons, kites and aeroplanes, was undertaken. The first twelve parts will be published monthly and the last two parts at the end of each year.

(7) *Library and Inquiries Section.*—The library which had gone into disorder during transit from Simla to Poona was re-arranged. Books, periodicals and pamphlets either purchased or received as presentation copies during the year numbered 785. The section is generally responsible for the preparation of monsoon and winter rainfall forecasts, the supply of special meteorological information, replies to scientific inquiries and the editing and distribution of departmental publications.

The routine publications of the department which are shown at length in the Administration Report for 1922-23 serve as the ordinary channels for the supply of information to the public. From time to time, however, special information is also supplied to the Meteorological Departments of England, Australia and Egypt. Special climatological and other meteorological data are also furnished to Government officials as well as to private firms on payment.

The following publications were issued during the year :—

1. *Scientific Notes, Volume I, No. 3.*—" Thunderstorms of Calcutta 1900-1926 " by V. V. Sohoni.
2. *Memoirs of the India Meteorological Department, Volume XXV, Part II.*—" Summary of Indian Rainfall for the fifty years, 1875 to 1924 ".—Departmental.
3. *Kodaikanal Observatory Bulletin No. LXXXII.*—" A brilliant Daylight Comet observed at Kodaikanal " by P. R. Chidambara Ayyar.

The following were in the press at the end of the year :—

1. *Scientific Notes, Volume I, No. 4.*—" On temperatures of Exposed Rails at Agra " by K. R. Ramanathan.
2. *Scientific Notes, Volume I, No. 5.*—" Frequency of Thunderstorms in India "—Departmental.
3. *Scientific Notes, Volume I, No. 6.*—" Correlations between Pre-monsoon conditions over north-west India and subsequent monsoon rainfall over north-west India and Peninsula " by Mukund V. Unakar.
4. *Memoirs of the Indian Meteorological Department, Volume XXV, Part III.*—" Data of Heavy Rainfall over Short Periods in India "—Departmental.

The number of institutions and individuals on the distribution lists of this department was 378 at the end of the year.

23. *Agra (Officer-in-Charge—Mr. G. Chatterji).*—In accordance with the general upper air extension scheme 11 new pilot balloon stations were established in different parts of India and 3 more were temporarily opened in north-east India to study the nor'westers. The thanks of this department are due to the Mysore and Travancore Governments for their kind co-operation in the collection of upper air data. Preliminary arrangements were made for the starting of upper air work at Seychelles. The opening of all these new stations involved the recruitment and training of the necessary staff and the collection of adequate equipment for the additional upper air observatories. The demand for hydrogen gas for balloon work was very great and Agra observatory had to arrange for an output of the gas nearly three times that of the previous year.

The daily routine duties, such as eye observation of various meteorological instruments and pilot balloon flights in the morning and the maintenance of a number of self-recording instruments were continued as usual. During the year 97 instruments were let off with balloons and 53 were recovered; the examination of their records led to a general confirmation of the results obtained in previous years. By means of the Chatterji upper air temperature indicator, which consists of a simple and inexpensive arrangement to indicate the level at which any definite air temperature is reached, the levels of given upper air temperatures in different months and at different hours of the day were determined. Balloons with recording instruments which come down automatically after reaching a certain height (christened "clown balloons" by Mr. Field) were used to obtain detailed records of humidity and temperature up to about 2·5 kms. above ground level.

A number of other investigations, both experimental and statistical, were also undertaken at the observatory. The test of airship fabrics received from the Royal Airship Works, Cardington, which was first undertaken at Agra in 1925 was carried on this year also.

An underground hut was built for the installation of a seismograph which was transferred from Simla to Agra on the move of the headquarters office to Poona.

An expedition led by Mr. Chatterji went to Jessore in Eastern Bengal in the middle of March 1929 to collect upper air data in connection with the study of nor' westers.

The pilot-balloon stations at Ambala and Lahore were inspected during the year.

24. *Colaba and Alibag (Officer-in-Charge—Dr. S. K. Banerji).*—As mentioned in the last year's Administration Report, the Bombay Daily Weather Report was discontinued during the year and instead, a duplicated weather summary was issued from Colaba at noon every day during the period May to November. The summary gives the principal features of weather with forecast for western India and the rainfall amounts registered during the previous 24 hours and also contains half-weekly weather and crop report from the 1st July to the end of November.

The routine operations of the observatories consisted, as before, in securing continuous records of autographic instruments, magnetic, meteorological and seismographic; taking eye observations of auxiliary and recording magnetic instruments five times a day and of the meteorological instruments three times a day. A number of experimental researches which were started at the observatory in recent years were continued and some new investigations were taken in hand. A further study of microseisms appeared to reveal the existence of three distinct types of these vibrations which are readily distinguishable from one another and are associated respectively with (1) southwest monsoon, (2) storms in the Arabian Sea and the Bay of Bengal and (3) local disturbances on the Bombay coast. An ionium collector for the measurement of atmospheric potential gradient was received at Bombay in November 1928 from the Carnegie Institution of Washington, and arrangements were made for obtaining continuous records of the variations of atmospheric potential gradient in the

open space near the sea front. Experiments on earth current measurements were continued and yielded interesting results. Two post-graduate students carried out investigational work in the observatory on thermal conductivity of soil and on atmospheric potential gradient.

Wireless time signals broadcast by Bordeaux were received regularly throughout the year. Whenever Bordeaux was not received, Rugby was heard. The reception of time signals transmitted by Calcutta and Nauen was discontinued from 1st May and 1st August respectively. The observatory rated and issued 51 chronometers and watches to R. I. M. and R. N. ships and collected 1,021 weather logs from ships calling at Bombay. The manuscripts of the Observatory Volume for 1924 were sent to the press and those for 1925 were nearly ready for printing. Considerable progress was also made in the preparation of the volume for 1926.

25. *Calcutta, Alipore (Officer-in-Charge—Mr. V. V. Sohoni).*—The usual work of the first class observatory was carried out satisfactorily. The pilot balloon station which had been located at Diamond Harbour was transferred to Alipore in February last.

The storm and flood warning work of this observatory has been described in earlier sections of this report. Other important duties of the Alipore Observatory are the determination of time by transit observations of stars and the wireless broadcasting of time signals at 14 and 22 hrs. I. S. T., supplying all Indian observatories with instruments and stores, keeping a stock of tested instruments and supervising meteorological observatories in northeast India.

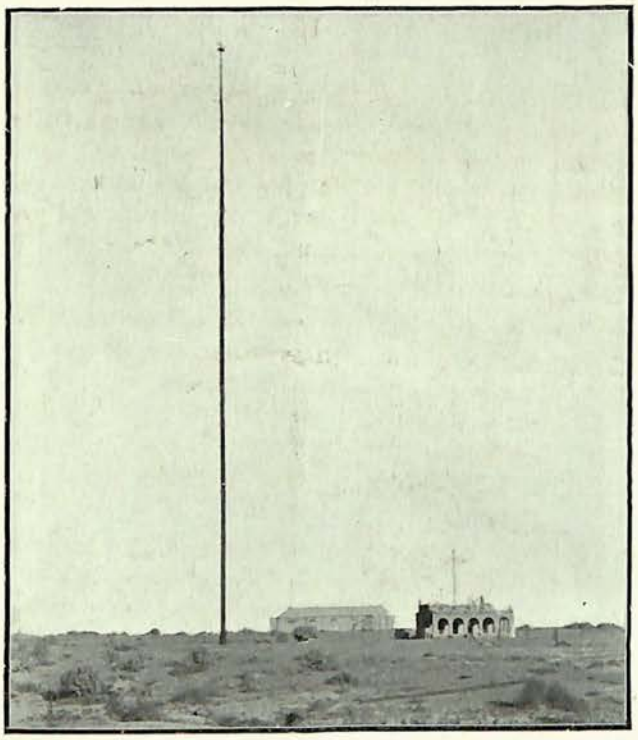
A scheme for the intensive study of weather over northeast India was put into operation from the 1st September 1928. It consisted of three sets of daily observations from 21 of the existing meteorological stations and of non-instrumental observations from 56 auxiliary stations; some of the observatories were equipped with autographic instruments.

The Calcutta office staff inspected 44 observatories in Burma and northeast India.

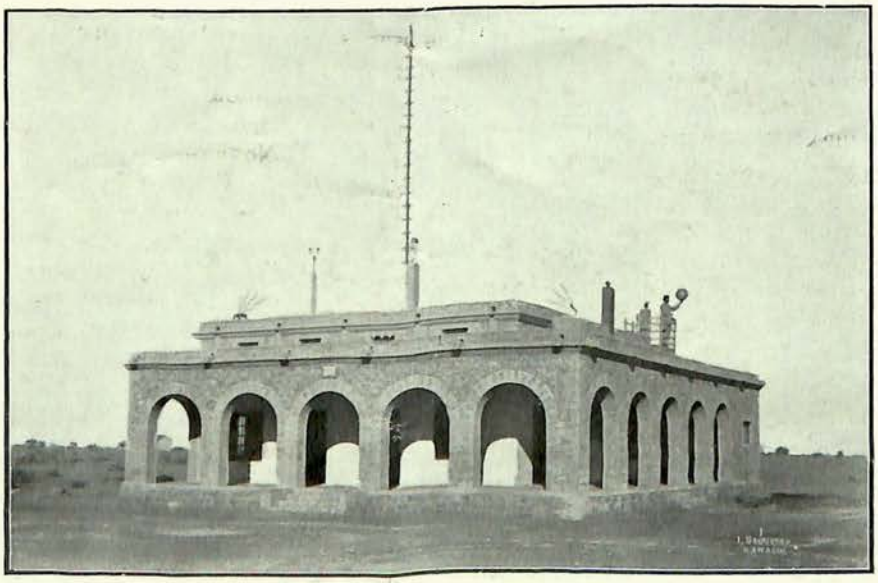
26. *Madras.*—The Madras Daily Weather Report was published throughout the year. One of the most important items of work for which the observatory is responsible is the supply of correct time to local shipping and through the Indian Telegraph system to the whole country, under the supervision of the Director, Kodaikanal and Madras Observatories. Comparisons with wireless time signals broadcast from foreign stations including Bordeaux and Rugby were also made daily as a check on the local time determination. Meteorological observations were made four times a day and the daily mean values obtained by applying corrections for the duirna variation derived from 20 years' observations. The observatory maintained, as usual, a continuous record of the chief meteorological elements by self-recording instruments and continued the daily pilot balloon observations. Besides the ordinary routine work, the daily values of meteorological normals based on data for the period 1891-1927 were also prepared.

27. *Karachi (Officer-in-Charge—Dr. S. K. Pramanik and then Dr. B. N. Banerji).*—Dr. B. N. Banerji on his return from Europe resumed his duties at Karachi in September, 1928. As the airship intended for the London-Karachi

METEOROLOGICAL OBSERVATORY, DRIGH ROAD, KARACHI.



260-FOOT MAST FOR THE MEASUREMENT OF TEMPERATURE GRADIENT NEAR THE GROUND.



OBSERVATORY BUILDINGS.

Photo engraved and printed at the Govt. Photozinco. Office, Poona, 1929

air-route was nearing completion and trial flights expected to commence in 1929, proposals were submitted to Government regarding the action to be taken for the intermediate stage of meteorological preparations for the coming of airships. These contemplate an extension of the present organisation by starting a few more reporting stations in the neighbourhood of Persia, equipping some of the existing observatories along the flying route with self-recording instruments and obtaining synoptic data from larger area than at present.

The observatory building at the Airship Base which was completed at the end of 1927-28 was equipped with self-recording instruments. The recording of ground and upper air observations, including visual observations of the hourly values of cloud and visibility, was started. Instruments for measurement of temperature gradient near the ground were received but could not be fitted up on the 260-foot mast, as the necessary electric power was not available at the aerodrome.

The R. A. F. at Drigh Road continued to extend their valuable co-operation and arranged for the collection of upper air temperature data by aeroplane flights on an average of 12 days per month.

At the forecasting centre, Karachi, a beginning was made with the study of weather conditions based on old data extending upto Italy to the west and Russia to the north.

During the year about 70 route forecasts were supplied by Karachi to aviators of many nationalities flying up to Karachi and across India. Among the noteworthy flights for which forecasts were issued may be mentioned the visit to India of the Under Secretary of State for Air on the flying boat " Iris " and the inauguration of the Dutch Air Mail Service to the Dutch East Indies.

28. *Kodaikanal* (*Officer-in-Charge—Dr. T. Royds*).—The observatory is mainly engaged on work in solar physics and astronomical researches, and the work during the calendar year 1928 has been summarised in the Annual Report of the Kodaikanal Observatory. During 1928 the solar activity maintained about the same level as during the previous year, although it would seem that the maximum of the spot cycle occurred in 1926. The highest prominence ever recorded at the observatory was photographed on November 19th, 1928 when an eruptive prominence reached a height of 910,000 km. above the solar surface before clouds intervened to prevent its further progress being pursued. Co-operation with other observatories was further increased during the year under the auspices of the International Astronomical Union, at whose request daily character figures for various features of solar activity from the 1st January 1928 were communicated for publication for the use of magneticians and others. The Marseilles observatory has been added to the list of observatories willing to send spectroheliograms regularly to Kodaikanal.

Spectrograms for the determination of the amount of ozone in the upper air were obtained at Kodaikanal on all suitable days from the 12th September 1928 onwards with Dobson's spectrograph which has been loaned to the observatory.

The revived post of Assistant Director was filled by the appointment of Dr. A. L. Narayan, D.Sc., formerly Professor of Physics at the Maharajah's College, Vizianagram, who joined duty on the 18th December 1928.

29. *Quetta and Peshawar.—(R. A. F. Meteorological Officers—Flight-Lieutenants R. P. Batty and R. G. Veryard respectively).*—These observatories which are fitted with a complete set of eye-reading instruments and a number of autographic instruments for recording important meteorological elements carried out the routine duties of a first class observatory. The R. A. F. Meteorologists at the local forecasting centres continued to issue general accounts and forecasts of weather over the Delhi-Peshawar-Quetta-Karachi air routes. They also issued detailed local forecasts and warnings, each for his own immediate neighbourhood. Special route forecasts were issued on about 180 occasions by Quetta and on approximately 250 occasions by Peshawar.

R. A. F. flying machines continued their meteorological observations at Peshawar and Quetta, and also at Kohat and Risalpur, and made the upper air data thus obtained available to this department. There were on the average about 23 ascents per month at Peshawar and 15 at Quetta.

30. *Other Observatories.—Departmental.*—There were at the end of the year 215 second to fifth class observatories maintained by the department. Two new third class observatories were opened at Vellore and Gwa. The old observatories at Quetta and Peshawar were closed and reports from the observatories under the R. A. F. meteorologists were substituted for them. The observatory at Lahore continued to function as a combined first class and pilot balloon station.

Non-Departmental.—Besides the above there were 51 non-departmental observatories whose records were scrutinized by this department and in most cases utilised in the Daily Weather Reports and other departmental publications. A new observatory was started at Coonoor and the existing observatories at Dehra Dun and Bahawalpur were equipped as daily reporting stations. The importance of these observatories need hardly be emphasised and the co-operation of the Indian States and public bodies for the furtherance of the study of Indian Meteorology is much appreciated.

Rainfall Registration.

31. The registration of rainfall has always been carried out under the control of Provincial Authorities. In 1889 a uniform system was introduced by the Government of India and the Director-General of Observatories was made the consulting Officer in connection with this work. His advice is sought regarding the starting of new raingauge stations, and he receives annual reports upon the efficiency of the work from the local controlling officers who are in most of the provinces the Directors of Agriculture or of Land Records.

The following table based on reports for 1928-29 shows the number of provincial raingauges and the raingauges in the Indian States at the end of

the year and number of inspections of these during the year, with corresponding figures for the preceding year for purposes of comparison :—

No.	Province.	No. of rain-gauges at the end of		No. of inspections.			Remarks.
		1928-29.	1927-28.	1928-29.	1927-28.	Change.	
1	Burma	215	214	204	229	—25	On the whole satisfactory.
2	Assam	126	124	116	108	+8	Equipment good.
3	Bengal	233	232	218	215	+3	Raingauges generally in good condition.
4	Bihar and Orissa ..	298	297	279	274	+5	Registration work satisfactory.
5	United Provinces ..	269	269	224	243	—19	Satisfactory.
6	Punjab	154	151	128	141	—13	These figures do not cover canal stations.
7	North-West Frontier Province.	31	31	28	23	+5	Inspected gauges found in working order.
8	Baluchistan ..	72	72	54	20	+34	All in good condition, defects promptly removed.
9	Bombay	304	304	264	244	+20	Good condition on the whole.
9 (*a*)	Western India States	27	27	26	26	0	Satisfactory.
9 (*b*)	Baroda	12	12	7	..	..	In good condition.
10	Rajputana ..	329	301	300	282	+18	Efficiently working.
11	Central India ..	198	195	154	155	—1	Generally good.
12	Jammu and Kashmir	33	33	28	24	+4	Generally good.
13	Central Provinces ..	115	115	94	93	+1	Defects removed promptly.
13(*a*)	Berar	42	42	41	39	+2	Do.
14	Hyderabad ..	14	14	14	14	0	In good condition.
15	Mysore	234	234	197	208	—11	Most of the stations satisfactory.
16	Coorg	9	9	8	7	+1	All in good order.
17	Madras	504	495	483	482	+1	In good condition.
					Net change	+33	

32. *Heavy Rainfall Reports.*—Heavy rainfall is often so very local that small unrepresented areas can have as much as 10″ without the Daily Weather chart conveying the least suggestion of the local inundations. In order that such useful data might be promptly available for the Daily Weather Report it was arranged in 1921 that reports of 5″ or more of rainfall at the Provincial raingauge stations should be telegraphed to the forecasting centres. The number of such telegrams received during 1928-29 was 256 as compared with 170 in the previous year.

33. *Snowfall Registration.*—Information as to the amount of distribution and time of occurrence of snowfall in the Himalayan and Afghan mountain areas was on the whole tolerably complete, and the thanks of the Department are due to the various officers who collected and forwarded the reports.

Concluding Remarks.

34. The Meteorological Department owes a large part of its usefulness to the sympathetic assistance it receives from other departments. Civil Surgeons and other officers of Government Departments help the meteorological work as honorary superintendents of observatories and in other capacities. The Posts and Telegraphs Department assist this department in the rapid transmission of meteorological information ; at the same time they allow their employees to act as observers.

Weekly telegrams are received from April to October from the Director, Royal Alfred Observatory, Mauritius and from the departmental observatories at Zanzibar and Seychelles. These telegrams give valuable information of the weather conditions in the Indian Ocean, and the department is indebted to these officers for the punctual transmission of the information. Thanks are also due to the Director of Royal Alfred Observatory for his courtesy in placing the meteorological data of that observatory at our disposal.

The department is greatly indebted for important information on meteorological conditions prevailing before and during the southwest monsoon to the Controller, Physical Department, Cairo ; the Directors of the observatories at Buenos Ayres, Santiago and Batavia ; the Astronomer Royal, Cape Town ; Director L'Observatoire Physique Central, Leningrad ; the Secretary, Friends' Industrial Mission, Banani Pemba, Zanzibar ; the Principal Medical Officer, Tanganyika Territory, Dar-es-Salaam ; the Commonwealth Meteorologist, Melbourne, Director Agriculture, Salisbury, Rhodesia ; Chief of the Weather Bureau, Washington, and to the various officers around the Indian frontiers who have collected and supplied valuable snowfall information.

The thanks of the Department are due to the Superintendent of Colombo Observatory for the very useful help he has rendered from time to time in connection with storm warning work. The Department is also grateful to the Director, Koninklijk Magnetisch et Meteorologisch Observatorium, Batavia, Java, who has arranged for daily weather telegrams to be sent from Sabang in Sumatra during the cyclone months April, May and October to December.

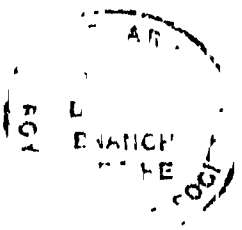
Thanks are also due to the Director General of Commercial Intelligence and Statistics for supplying information in connection with the study of correlation between weather and crops and to Mrs. M. La Frenais, Srinagar, for her permission to reproduce in the present issue of the Administration Report a photograph showing the great flood in Kashmir in September 1928.

POONA ; T. ROYDS,

The 19th August 1929. Offg. *Director General of Observatories.*

M30CPB(DGofObs.)—450—3-10-29—G1PS

Report on the Administration of the Meteorological Department of the Government of India in 1929-30.



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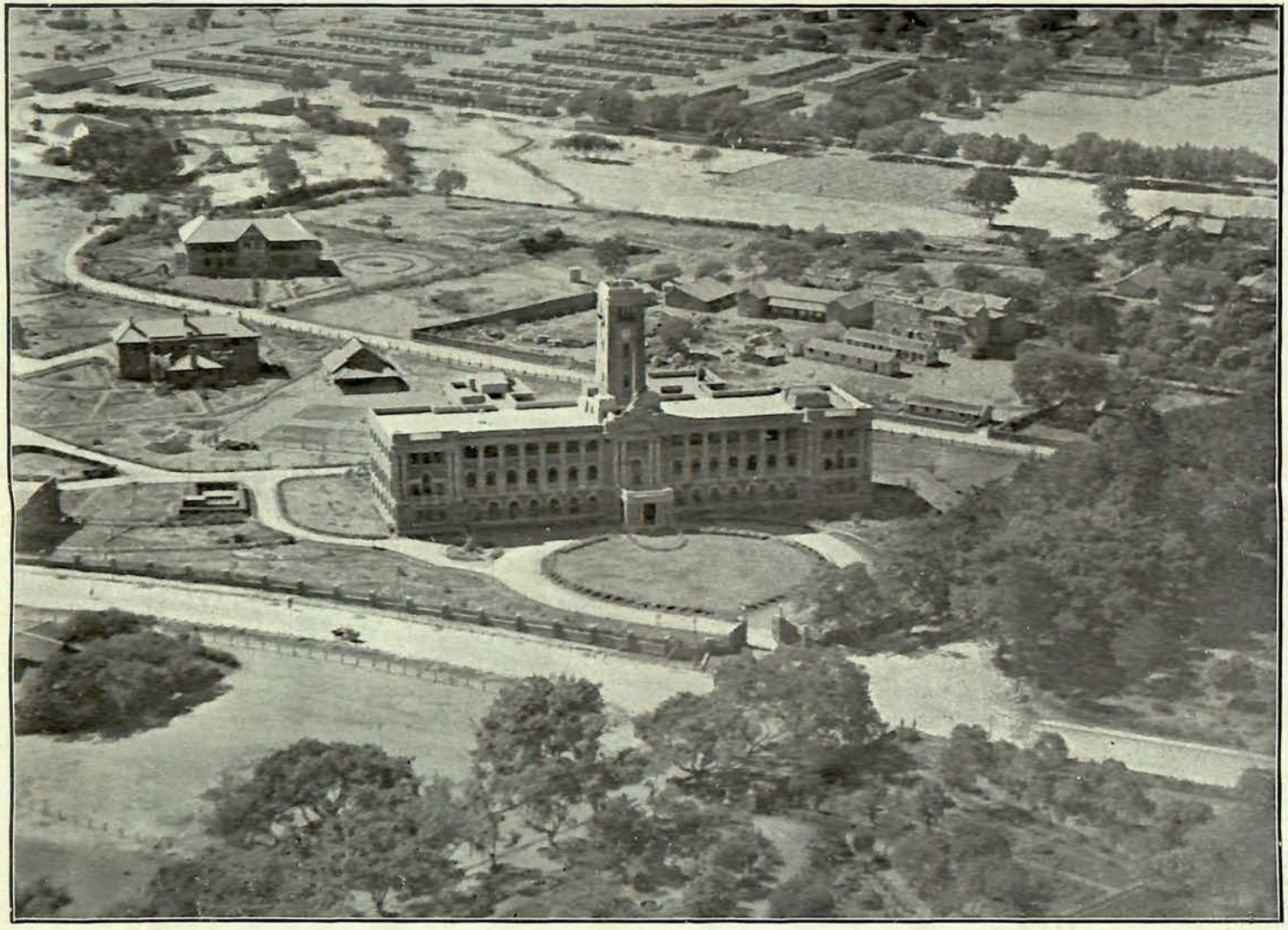
AGENT IN PALESTINE.—Steimatzky, Jerusalem.

AERIAL VIEW OF METEOROLOGICAL OFFICE, POONA.



By courtesy of the R.A.F.

Plate I

Report on the Administration of the Meteorological Department of the Government of India in 1929-30.

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CHIEF FEATURES OF THE YEAR.

The activities of the department during the year were largely directed towards the formulation or development of schemes for weather services along new or proposed air-routes. The London-Karachi Air Mail service started in April 1929, the State Air Mail Service between Karachi and Delhi began operating towards the end of December, and other air-routes, particularly those between Delhi and Rangoon, are likely soon to be opened. These air services gave a new orientation to meteorological work in India and necessitated a more or less complete overhaul of the existing weather-reporting arrangements. In accordance with various international recommendations specifying the nature of information to be supplied to aircraft it became necessary to prepare two weather charts per day at regional forecast centres in India, to raise to 2nd class status most of the existing third class weather reporting observatories, and to open a number of new observatories. Fresh instructions for observers were drawn up, and new improved weather codes and registers for reporting and recording observations were prepared. These were introduced at observatories over the region extending from the Persian Gulf to N. W. India and will also be introduced elsewhere as air-routes extend. Arrangements for the exchange of synoptic weather reports between the

meteorological office at Karachi and forecasting centres in Egypt and Iraq, as well as the R. A. F. centres at Quetta and Peshawar, were completed early in April 1929, immediately after the new short wave wireless set was installed at the Karachi Civil W/T station. A forecast centre under a meteorologist was opened at Delhi in November 1929 and was made responsible for the supply of weather reports and forecasts to the State Air Mail and to other aviators using the Jodhpur-Delhi and Delhi-Allahabad routes. The forecast centre at Karachi took up the additional responsibility of weather service for the Karachi-Jodhpur air-route.

2. The Delhi-Calcutta and Calcutta-Rangoon routes were being planned during the year and proposals were submitted to Government regarding the division of meteorological responsibilities among the existing forecast centres at Delhi and Calcutta and the new forecast centre to be opened at Rangoon. These proposals included the equipment of observatories at aerodromes with autographic instruments, the opening of new observatories, the raising of existing third class observatories to 2nd class status and the provision of a closer network of pilot balloon stations having two flights a day. Early in 1930 an officer was sent out to examine and select sites along the Calcutta-Rangoon route preparatory to the development of a meteorological organisation. Owing to the increase in the number of pilot balloon stations as well as the number of daily balloon flights, the duties of the Agra Upper Air Observatory had grown considerably and the consumption of hydrogen was becoming so large that additions to the existing plant were proving inevitable. Proposals were therefore made to Government to extend the hydrogen factory and to increase the staff at Agra. In addition to these detailed schemes for air-routes across N. India, an estimate of the total ultimate expenditure on weather services that would be required to meet the probable developments of aviation throughout this country was also submitted to Government. In this it was shown that telegraphic expense would be the preponderating item in the annual budget, especially after the withdrawal by the telegraph department of all concessions hitherto enjoyed by this department.

3. The Director-General of Observatories went on deputation to represent India at the Empire Meteorological Conference held in London in August and the International Meteorological Conference in Copenhagen in September, 1929. The Empire Meteorological Conference afforded an excellent opportunity for the discussion of those special meteorological problems which affect the British Empire, as distinct from the wider family of nations, problems mainly connected with the development of aeroplane and airship routes within the Empire, maritime meteorology, broadcasting of synoptic weather reports and agricultural meteorology. The International Conference at Copenhagen was preceded by meetings of nine Standing Committees which discussed in detail a very wide range of subjects, requiring the international co-operation of meteorologists. The Committees' reports were considered in the plenary sessions of the Conference which passed a large number of resolutions aiming at unifying methods of observation, calculation and publication and at co-ordinating programmes of work in matters that depend for their success on the close and efficient co-operation of the meteorological services of various countries. In the new International Weather Code, drawn up and recommended by the Conference, tropical phenomena were incorporated in a larger measure

than before and it is now possible for tropical countries to make use of international specifications to an extent that was not practicable formerly. The Indian weather codes are being revised accordingly and will be brought into still closer line with international specifications. The Director-General of Observatories also attended a Naval Meteorological Conference held in Colombo from 17th to 19th March 1930, at which the possibilities of increased co-operation between H. M. Ships and the weather services in India and Ceylon were discussed and various recommendations were made. This department was also interested to some extent in the results of the important International Maritime Conference that met in London in April and May 1929 and drew up a new International Convention for the Safety of Life at Sea. In this Convention certain provisions were laid down regarding marine meteorology and, if the Convention is ratified, developments in that branch of the department's activities may become obligatory.

4. On the scientific side, apart from routine investigations, there was much fresh activity in the department during the year. Various upper air studies concerning the wind and thermal structure of the atmosphere over India and other countries were continued at Poona and Agra. The expedition to study upper air conditions in Bengal during the nor'wester period in 1929, led by Mr. G. Chatterji, collected much interesting data which are being analysed and studied at Agra. The increasing interest in the study of the structure and movement of storms in Indian seas from the physical point of view is evidenced by the papers of Dr. S. C. Roy and Mr. A. K. Roy in the "Beiträge zur Physik der Atmosphäre" and of Dr. K. R. Ramanathan and Mr. A. A. Narayana Ayyar in the departmental Scientific Notes. A preliminary investigation to derive formulæ for the forecast of the winter wheat crop in the Punjab from meteorological data was carried out by Rao Saheb M. V. Unakar. Dr. S. K. Banerji continued his interesting researches on the electricity of thunderstorms and of microseisms associated with storms and monsoon fronts on the Indian seas. His study of the polarity of pre-and post-monsoon thunderstorms tends to support the breaking-drop theory of Dr. G. C. Simpson regarding the origin of thunderstorm electricity. In solar physics, a paper on the relative variations in the extent of bases and heights of prominences accompanying variations in their areas was contributed by Mr. P. R. Chidambara Iyer; and studies in the analysis of spectra of ionised atoms were continued by Dr. A. L. Narayan and his students.

Marine Meteorology; Storm Warnings.

5. *The system of storm warning for ports and shipping.*—Warnings for the approach of cyclonic storms or of bad weather were issued as usual from Poona and Calcutta to ports and shipping in the Arabian Sea and the Bay of Bengal respectively. The number of ports in the warning list was 37 on the west coast of India and 28 on the Bay of Bengal as in the previous year. In addition to these regular ports, there were 8 river ports, 14 River Police Stations and 44 District Police Stations on the Calcutta warning lists. Three divisional officers in the district of Backerganj were added to the list and now receive information on occasions when the warning or danger signal is ordered at river ports and Police Stations, in addition to the occasions when great danger signals are ordered. The supply of the latest weather information to shipping

at sea by means of weather bulletins broadcast twice daily continued as usual. The total number of wireless weather bulletins and warning messages issued during the year was 12,746.

6. *Services to ports around the Bay of Bengal.*—Warnings were issued during the year for 35 periods of disturbed or suspicious weather. On three of these occasions the disturbances developed into storms, two of which were moderately severe. The first one formed into a depression near Lat. 17½°N. Long. 91½°E. on the 2nd June. Advancing northwards it developed into a storm and crossed the coast between Cox's Bazar and Chittagong. This storm was of the monsoon type with light to moderate winds near the centre and consequently no great damage was done. The next storm formed at the head of the Bay on the 15th July and crossed the coast near Saugor Island on the 17th. Several steamers at the head of the Bay as well as light-vessels in the approaches to the Hughly experienced very rough weather during the passage of the storm. Reports on the warnings were received by the meteorologist, Calcutta from 26 Port Officers, all of whom expressed satisfaction with the warnings issued. In order to provide opportunities for discussing with ships' officers the daily wireless weather bulletins and the wireless storm warnings, arrangements were made during the year for a responsible meteorological officer from Alipore Observatory to attend the Port Office at Calcutta between the hours of 12 NOON and 1 P.M., whenever weather conditions warrant a visit, or whenever two or more ships' captains express a wish for a personal discussion about the prevailing weather conditions or matters of general interest regarding marine meteorology.

7. *Services to Arabian Sea ports.*—Warnings for disturbed and squally weather were issued on 25 occasions. The most important of these disturbances formed with centre near Lat. 12°N., Long. 70°E., on the morning of the 27th September, on which day widespread rain fell in the Peninsula. Moving northwestwards, it began to intensify on the afternoon of the 28th and was probably a storm by the morning of the 30th, its centre at 8 hrs. on that day lying near Lat. 18°N., Long. 62°E. It then weakened rapidly, while moving in a westnorthwesterly direction, and crossed the Arabian Coast, between 19° and 20°N., on the morning of the 1st October. Reports on the working of the warning system for the Arabian Sea area were received from 16 officers on the warning lists. All the reports stated that the warnings were timely and satisfactory and that no change in the present system was necessary.

8. *Exchange of information with ships at sea.*—The chief sources of marine data are wireless weather messages from ships at sea and extracts from weather logs of ships calling at the principal ports on the Indian seaboard. The object of the system of radio messages from ships is to attain greater efficiency in cyclone-warning work. It was started in 1914, suspended during the War and resumed in 1921. Since that year there has been a steady increase in the use of this system by ships in Indian waters ; the number of ships' messages from the Bay and the Arabian Sea during the year totalled 4,635 (from the Bay 2,872 and from the Arabian Sea 1,763), in comparison with 4,342 in the previous year, 3,689 in 1925-26 and 956 in 1921-22. Special acknowledgment is made of the aid rendered by steamships which sent more than 40 weather

messages during the year : they are listed below, with the number of messages sent :—

Badarpur	158	Egra	59
Barpeta	157	Arankola	58
Aungban	124	Hosang	58
Singu	100	Meerkerk	56
Dara	96	Maharaja	53
Ethiopia	81	Aronda	49
Masimpur	80	Ahmedi	47
Schiekerk	70	Merkara	47
Havildar	68	Jalapalaka	45
Cocanada	68	Streefkerk	45
Vita	63	Garbeta	43
Magdapur	60	Yuensang	42

The increase in the number of ships' observations, indicating willingness on the part of ships' officers to co-operate with weather services ashore, is most gratifying ; but even so, the forecasting officers frequently lack, at critical times, ships' observations from the vicinity of the centre of a disturbance at sea and find themselves compelled to draw their inferences from and base their broadcast messages to ships on coastal observations alone. It may be that sometimes it happens that storm centres develop in ocean areas far from the normal shipping routes, *i.e.*, in areas where there are few, if any, ships to send reports. Also commanders of ships with the aid of the wireless weather reports are now better able by suitable navigation to avoid storm areas. Despite these facts it is felt that improvement in the system is still possible, and it would be most helpful if co-operating captains could induce others to take a share in this organisation of supplying information from sea. It is worthy of note that a message, which may appear to be colourless by itself, is frequently of great use, when considered along with other observations plotted on a chart. There is a great future for synoptic meteorology at sea ; but still more extensive co-operation between the sailor and the meteorologist is needed to make full use of the great aid of wireless weather reports to navigation and safety of life at sea.

9. It will be recalled that an International Maritime Conference met in London in April and May 1929 and drew up a new International Convention for the Safety of Life at Sea which is likely to be ratified by many countries

and come into force in 1931. Chapter V of this Convention relates to the Safety of Navigation and contains in Article 35 some decisions with regard to meteorological services. The following are extracts from this article :—

" The Contracting Governments undertake to encourage the collection of meteorological data by ships at sea, and to arrange for their examination, dissemination and exchange in the manner most suitable for the purpose of aiding navigation.

In particular, the Contracting Governments undertake to co-operate in carrying out, as far as practicable, the following meteorological arrangements :—

(*a*) to warn ships of gales, storms and tropical storms, both by the issue of wireless messages and by the display of appropriate signals at coastal points;

(*b*) to issue daily, by radio, weather bulletins suitable for shipping, containing data of existing weather conditions and forecasts;

(*c*) to arrange for certain selected ships to take meteorological observations at specified hours, and to transmit such observations by wireless telegraphy for the benefit of other ships and of the various official meteorological services; and to provide coast stations for the reception of the messages transmitted;

(*d*) to encourage all ship-masters to inform surrounding ships whenever they experience wind force of 10 or above on the Beaufort scale (force 8 or above on the decimal scale).

* * * * * * * * * * *

Forecasts, warnings, synoptic and other meteorological reports intended for ships shall be issued and disseminated by the national service in the best position to serve various zones and areas, in accordance with mutual arrangements made by the countries concerned.

Every endeavour will be made to obtain a uniform procedure in regard to the international meteorological services specified in this Article, and, as far as practicable, to conform to the recommendations made by the International Meteorological Organization, to which organization the Contracting Governments may refer for study and advice any meteorological questions which may arise in carrying out the present Convention."

10. Apart from ships' wireless messages, an important source of data for later study is the log extracts collected by the marine clerks in Calcutta and Bombay and other agencies mentioned below. The old log form was replaced by two new forms—one for use during ordinary weather and the other during disturbed weather. These forms were designed to secure the collection of fuller marine data on a more elaborate scale, and the British India Steam Navigation Co., the Scindia Steam Navigation Co., and the Asiatic Steam Navigation Co., kindly arranged with their ships' captains to copy and despatch such log forms to this department direct. The Port authorities at Rangoon continued to render help by allowing the observers of the Time Ball and Tidal Observatory of the Port Commissioners to collect ships' data. Occasionally in special cases logs of steamers with experience of distrubed weather were collected at Madras ; and the Colombo Port authorities also helped this department similarly whenever requested. A total of over 5,000 logs was recorded at the end of the year as against over 4,000 collected during the previous year. The policy of lending meteorological instruments to ships was pursued slowly but steadily. During the year under review two more ships were added to the list of those supplied with meteorological instruments, thus bringing their number to 16. The weather logs from the captains of these 16 steamers were received regularly.

Inland Weather Warnings and Forecasts.

11. *Heavy Rainfall Warnings.*—The majority of the officers to whom warnings of heavy rain on land were issued from Poona and Calcutta are district officers and officers of the irrigation, railway and other departments. The number of officers in the warning list was 263 including 31 officers of the Telegraph Department who generally required warnings for strong winds. The system worked satisfactorily during the year ; the special inland forecasts and warning messages issued from forecasting centres numbered 3,033, while 1,073 telegrams of heavy rainfall reports were sent direct to various officers by the local meteorological observers. Reports on the working of the warning system were received from 113 officers, who have expressed satisfaction with the warnings issued. The only criticism received was that contained at the end of the first of the following extracts from letters regarding warnings :—

From Director of Agriculture, Baroda State, dated 13th January 1930 :—

> ' 14 warnings were received, out of which all except three eventualised.....The forecasts have been of great general utility although it sometimes happens that the weather precedes the wire."

From District Engineer, B. N. Railway, Cuttack :—

> " The warnings received from the Meteorological Department were distinctly useful. In the case of floods at Cuttack, it enabled me to take measures to help all our patrols out in ample time before any danger occurred."

From a letter dated the 23rd December 1929 from the Executive Engineer, Karnal Division, to the Superintending Engineer, Western Jumna Canal Circle :—

> " There was only one serious flood in the Jumna this year on 17th August 1929 and the warnings issued in connection with this were very accurate indeed and the forecast amply fulfilled. None of the warnings proved entirely abortive. As even if no serious flood came down the river, local rainfall was received either in the vicinity of Tajewalla itself or in the Kumaon hills. The warnings served a distinctly useful purpose and should be continued."

The warnings for heavy rain are also included in the Daily Weather Telegram, as mentioned in previous reports. Officers and others who are interested in following the sequence of weather from day to day and wish to be kept informed about the probable areas of heavy rainfall are therefore advised to become subscribers to the Daily Weather Telegram issued from Poona, for which the subscription is Rs. 10 per month.

12. *Aviation Forecasts.*—Some information about the actual and proposed developments of meteorological services in connection with aviation in India has already been given at the beginning of this report. With the inauguration of the airmail service to India early in April and its extension to Delhi in December 1929, the demand for aviation forecasts has become a regular feature at the Meteorological Office at Karachi and at the new office at Delhi, both of which on flying days kept a special watch, in order to acquaint the Imperial Airways pilots of the latest changes in weather and to issue prompt warnings of adverse weather whenever necessary. The Meteorological Office

at Calcutta issued forecasts in connection with three special test flights of Southampton flying boats from Singapore to Calcutta and back. Forecasts were also supplied regularly to R. A. F. pilots by the Meteorological Officers at Quetta and Peshawar and occasionally by other forecasting centres to aviators of various nationalities, including Dutch, French, Indian and Siamese, and to the Southampton flying boats flying over the Persian Gulf region.

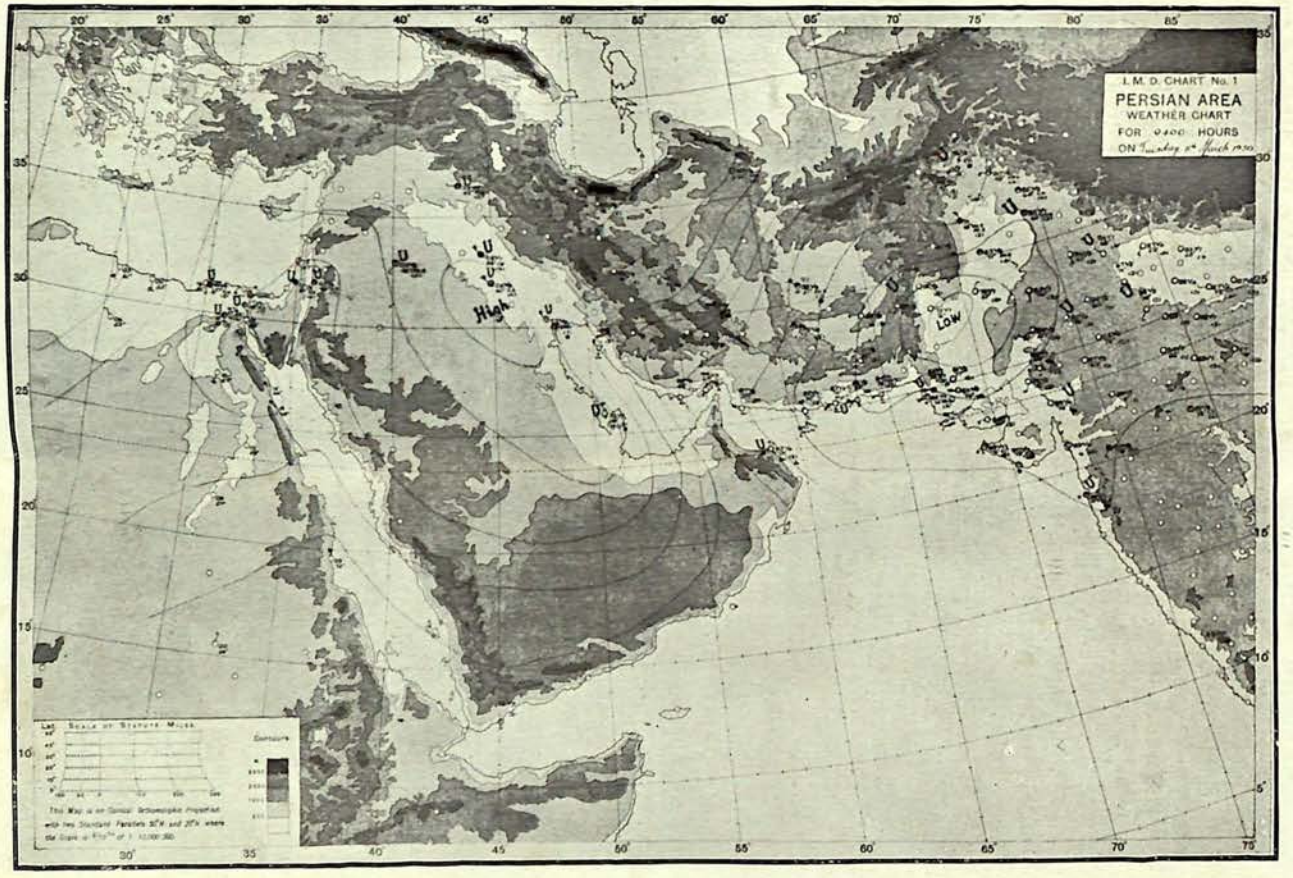
During his visit to Karachi in December 1929 the Director-General was interested to meet an Airways pilot who had called at the Office to express his thanks for the weather reports and forecasts which had been sent to him during the previous two or three days on his journey from Baghdad to Karachi. In his logs for the flight he had noted on the 9th December " Forecast telegraphed to Jask very good and most useful " and on the 10th December " Forecast from Karachi again very good and useful, Pasni aerodrome entirely under water, Gwador very soft ". In conversation he mentioned that the actual reports and the upper wind forecasts indicating the best flying heights, saved him from a forced landing and from possible disaster. At all heights up to the usual flying heights, the winds were adverse and the machine did not carry sufficient petrol to allow the pilot to reach Karachi in face of such winds. At higher heights, however, the winds were more favourable and the pilot, taking advantage of the knowledge given him about these winds, was able to reach Karachi with a little quantity of petrol in reserve.

Besides the regular storm-warning work, occasional requests are received from Government officials and private firms for the issue of special weather reports and forecasts. Such requests are always complied with.

Offices and Observatories.

13. A list of the staff of the India Meteorological Department, as it stood on the last day of the year under review, is given in Appendix A. The general organisation and duties in each office have been described in a separate publication entitled " Note on the Function, Organisation and Present Developments of the Indian Meteorological Department ", first published in January 1930 and to be revised in future once a year. An interesting feature in connection with the general administration and scientific progress in the Department is the Annual Conference of Officers, of which the first session was held in July 1929. In July 1928, the Headquarters Office at Poona was opened and all officers in charge of sub-offices were invited to the function. The idea of an annual conference was mooted at that time and Government were pleased to agree to the proposal. At the 1929 Conference, in addition to officers of the department from regional centres, heads of other meteorological organisations in India were also invited. These were : the Royal Air Force Meteorological Officers at Quetta and Peshawar, the Director of the Nizamiah Observatory, Hyderabad, and the Meteorological Reporter to the Government of Mysore. The Director-General of Observatories reviewed the previous year's progress in his opening remarks, and a week was spent in discussion of administrative and technical matters and lectures on various scientific subjects, such as the Eclipse Expedition to Siam ; nor'wester studies in Bengal ; electric field of overhead thunder-clouds in Bombay ; spectra of ionised atoms ; correlation between

SPECIMEN OF KARACHI WEATHER CHART.



Such synoptic weather charts are prepared twice daily at the Karachi Meteorological Office which is entrusted with the weather service for the Bushire-Jodhpur Air Route. In the picture circles with arrows and figures indicate the reporting stations: those that are marked U take pilot balloon observations also for estimation of speed and direction of upper winds.

G. P. Z. P. 1930

Plate II

Indian rainfall in July and August and pressure distribution over the globe ; upper air temperatures and entropies over the northern hemisphere in summer and winter, eddy viscosity and sea waves, and a modification of Dines' meteorographs. His Excellency the Governor of Bombay, Sir Frederick Sykes, visited the office one evening during the Conference when an exhibition and demonstrations illustrating the various activities of the Department were arranged.

14. *Headquarters Office, Poona.*—The scientific work of the department has been summarised already in the "Chief Features" at the beginning of this report. In this connection it is worth mentioning that during the year about 20 colloquia were held in the Poona Office, various officers and members of the staff taking part by reading papers on original work or summarising important papers published in foreign journals. On the administrative side the main new items that engaged the attention of the various sections of the office were related to the meteorological arrangements for civil aviation in India ; a brief account of these is included in some of the following sectional reports :—

(a) *General Section.*—This section is responsible for the administration of Headquarters and sub-offices and deals with budget and accounts, establishments, general registry, all technical questions involving change of policy or fresh expenditure and the co-ordination of the technical work of the Department. During the year it had to devote special attention to the preparation of various schemes necessary to meet the needs of the proposed extensions of air routes in India. The section had also to cope with the administrative work involved in giving effect to the sanctioned aviation schemes, including the starting of a new forecasting centre at Delhi. An interesting proposal that was made during the year was one for inaugurating a new section of agricultural meteorology. The Royal Commission on Agriculture in their report of 1928 recommended that the Council of Agricultural Research, in consultation with the Director-General of Observatories and the Director of the Central Bureau of Statistical Information, should, as soon as possible, prepare a programme of research work in agricultural meteorology, settle the relative urgency of the various items in it, having regard to the men and money available, and make suggestions for the allocation of the work among the different departments. This department prepared a draft scheme for the formation of a nucleus of such a branch for the study of agricultural meteorology. The scheme of work covered two heads—statistical and experimental—and was submitted to Government for consideration in the Department of Education, Health and Lands and in the Imperial Council of Agricultural Research. Proposals were also sent to Government for the sanction of a few research scholarships and for additional staff at the Headquarters Office in order to cope with the increased work.

(b) *Weather Section.*—The functions of this Section have been partly outlined in previous pages dealing with the issue of warnings of storms and heavy rain. In addition to these, this Section is responsible for—

(1) the issue of Daily Weather Telegrams giving the general weather situation over the country along with a forecast for the succeeding 24 hours,

(2) the issue of Daily, Weekly and Monthly Weather Reports, and

(3) the preparation of portions in the Annual Summary relating to weather.

A new Weather Message Code on the lines of international convention was prepared by this Section. The new code makes greater demands on observers and its introduction at stations in northern India has led to a considerable addition to the duties of this Section in connection with

the checking of the observers' daily telegrams and the monthly registers which contain observations taken twice a day.

(c) *Observatories Section.*—It is the duty of this Section to maintain at an efficient standard the second, third, fourth and fifth class observatories under its charge, *i.e.*, all such observatories excepting those under the charge of the Meteorologist, at Calcutta and Karachi. On the introduction of the New Weather Message Code new instructions for observers were drawn up and new registers for recording observations were prepared. Of the 96 observatories, which were visited during the year by inspecting officers from headquarters and sub-offices, the status of 61 third class observatories was raised to second class and daily afternoon observations from these 61 observatories began to be telegraphed to Delhi or Karachi to supply data for the preparation of afternoon weather charts at these forecasting centres. In connection with the Bushire-Rangoon Aviation Scheme, 36 new observatories were started or proposed. A cloud atlas for departmental use was printed and distributed to all observers. A new "Handbook of Instructions to Observers" at second and third class observatories was compiled and sent to press; this book will meet a long-felt want and will replace the old "Instructions to Observers", which has been out of print for many years.

(d) *Marine Section.*—This Section carried out its usual duties of co-ordinating work in connection with the regular collection, examination and study of ships' weather logs for the study of storms and cyclones at sea and of maintaining contact with shipping interests.

(e) *Instruments Section.*—A small laboratory was set up to provide facilities for experimental investigations on meteorological problems. The workshop was fully equipped and the repair of barometers and other instruments, belonging to this department, was undertaken. There were many old unserviceable anemometers lying in the departmental store, and out of these an improved type of anemometer containing a simpler mechanism and ball bearings on the top of the rotating spindle was evolved. In this new type, the old dial was replaced by small meters like the milometers of bicycles. The new product has been found to be very sensitive, neat-looking and easy to read. Out of condemned stock, 80 old anemometers were remodelled at a total cost of about a thousand rupees which is only one-twelfth of the cost of 80 new anemometers.

(f) *Upper Air Section.*—Sounding balloon work was continued at Poona, and with the permission of His Exalted Highness the Nizam of Hyderabad and the help of the Director of the Nizamiah Observatory, Begumpet, sounding balloons were also liberated from the Nizamiah Observatory during the period 10th August to 10th November. During the period under review 87 meteorographs were sent up of which 48 were recovered. Observations of upper air temperatures and humidities obtained from ascents of R. A. F. aeroplanes at Peshawar, Quetta and Karachi were tabulated in a form suitable for publication. The regular publication of upper air data in 14 parts, as mentioned in last year's report, was commenced this year. Part of the data for 1928 has been published and the remainder is in press. In collaboration with Agra and Karachi Offices, the Section prepared monthly normal isobars and wind roses for 0·5, 1, 2 and 3 km. above sea-level over India and the neighbourhood and the normals of monthly upper winds over 8 stations in India.

(g) *Library Section.*—The classification and indexing of the publications in the library was in progress and about 10,900 titles were added to the classified list bringing the catalogued total up to about 21,300. Books, periodicals and pamphlets, either purchased or received as presentation or exchange copies during the year numbered 731. The Section is responsible for the preparation of monsoon and winter rainfall forecasts, the supply of special meteorological information in reply to enquiries and the editing and distribution of departmental publications. Special information is sent occasionally to meteorological

centres in England, Australia, America and Egypt. The number of institutions and individuals on the free distribution lists of this department was 414 at the end of the year. Detailed information about the routine and research publications of the department is given in Appendix B at the end of the report.

(*h*) *Climatology Section.*—This Section checks the accuracy of the records of surface meteorological data, prepares the meteorological tables for the routine publications of the department, and supplies periodical meteorological data and reports on meteorological conditions to various Government officers. The advisory functions of the Director-General of Observatories with regard to the registration of rainfall, the publication of the rainfall tables of certain provinces and the collection and issue of the volumes of "Daily Rainfall" and "Monthly Rainfall of India" are also carried out by this Section. A brief account of the registration of rainfall carried out under the control of provincial authorities is given in a subsequent paragraph. During the year a new and revised edition of the "Rainfall Organization Circular" was published and information was collected to improve the net-work of raingauge stations in certain sparsely represented areas.

15. *Upper Air Observatory, Agra.*—The administration of 31 pilot balloon stations, including 3 temporary stations in northeast India for the study of nor'westers and the stations at Aden and Hyderabad which were started during the year, was carried on as usual. Six pilot balloon stations were inspected and arrangements for opening additional pilot balloon stations under various aviation schemes were in progress. The hydrogen plant was originally intended to supply gas to 18 stations having one flight daily but now its output has been increased so as to supply nearly double the number of stations, most of which have two flights daily; the year's output of about 1,65,300 c. ft. has been made possible only through the devoted attention and care of the staff.

Of the 124 sounding balloons with Dines' meteorographs, that were let off, 60 were recovered. A large number of records extending up to the stratosphere were obtained by using balloons made of Vulpro rubber tissue. Determination of definite temperature levels in the free atmosphere by means of the temperature indicator developed by Mr. Chatterji was started as an experimental measure at Poona, Agra, Lahore, Dacca, Alipore and Madras, and results of the observations were telegraphed to various forecasting centres. During the nor'wester months of April and May 1929 an expedition under the senior meteorologist was sent from Agra to Jhikargacha (some 50 miles north-east of Calcutta) to study the upper air conditions over Bengal during the nor'wester season.

The two horizontal Omori-Ewing seismographs which were formerly in Simla were installed in an underground room, and have been in operation since August 1929. The test of airship fabrics received from the Royal Airship Works, Cardington, was continued during the year.

The University of Agra at the instance of the Vice-Chancellor suggested in 1927 the introduction of meteorology in the curriculum of post-graduate study. This department was asked to help and with the concurrence of Government it was decided that officers at the Agra Observatory be permitted to give a course of lectures and demonstrations on meteorological theory and practice for an honorarium of Rs. 500 a year. Such classes in meteorology for post-graduate students were started in November 1929.

16. *Colaba and Alibag Observatories, Bombay.*—A weather summary containing the principal features of weather over western India and the chief rainfall amounts has taken the place of the Bombay Daily Weather Report since the commencement of the issue of the Indian Daily Weather Report from Poona. The material for this is telephoned from Poona to Colaba. The issue is limited to the period 1st May to 30th November and includes from 1st July onwards a bi-weekly weather and crop report for districts.

The routine meteorological, seismological, magnetic and time work at Colaba and Alibag Observatories was carried on as in previous years. Wireless time signals broadcasted by Bordeaux and Rugby and several other broadcasting stations were received regularly. During the year 105 chronometers and watches were received for custody, 41 were issued to R. I. M. ships, 24 to R. N. ships and 35 were returned to England for repairs. Extracts from weather logs were collected from 1,078 ships and sent to Poona and Calcutta. The Observatory volumes for the year 1924 and 1925 were printed and distributed, while the manuscripts of the volume for 1926 were sent to press. Arrangements were in progress for setting up an old Wiechert's vertical seismograph. To collect more autographic meteorological records at short distances apart during the passage of a monsoon front, barographs and thermographs were installed at Alibag, and at Santa Cruz and records were collected during May and June. Some valuable records were obtained from the earth-current recording apparatus which was kept in action for a considerable part of the year at the Alibag Observatory.

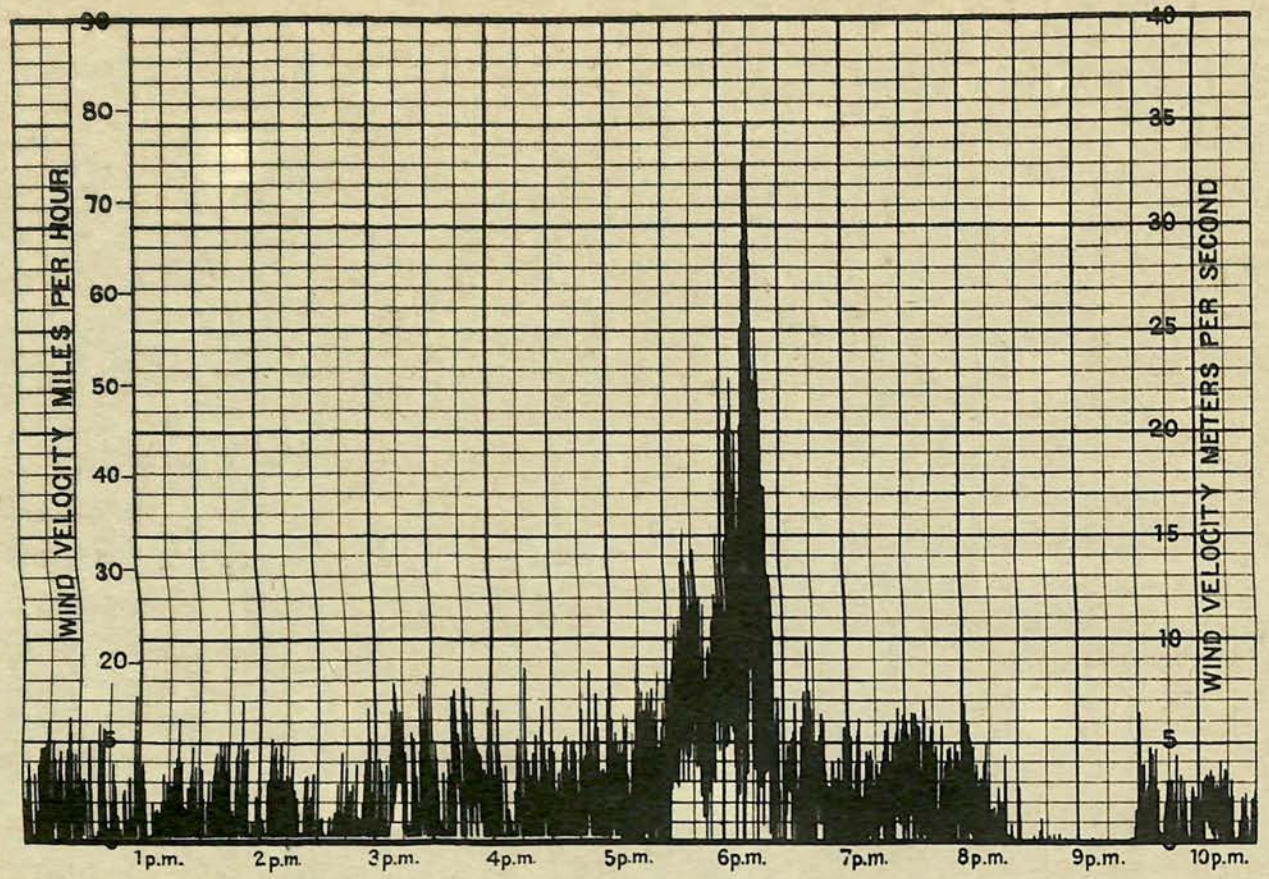
Four research students, two from the Royal Institute of Science and two from Wilson College, were actively engaged in research work on meteorological problems under the direction of the Meteorologist. Two of them, Mr. R. V. Barave and Mr. V. K. Shah prepared the undermentioned theses for submission to the University, respectively :—

(1) On the properties of the liquid vortices by Oberbeck's experiments,

and (2) A survey of the electric field in the Colaba Observatory and its comparison with that at other stations.

An investigation on the electric field of overhead thunderclouds conducted by the Meteorologist proved to be of considerable interest and importance. The experimental equipment consisted of two Bendorf's self-recording electrometers joined to a double-nozzle water-dropper and ionium collector respectively. Thunderstorms of the line-squall type occasionally pass over Colaba Observatory during the pre-monsoon and post-monsoon months, during the burst of the monsoon and also during weak monsoon periods. They generally move from the sea towards land and may occur at any time during the day or night. Experiments showed that unitary thunderclouds gave very similar records of field changes. The changes suggest that the front part of these clouds is negatively charged, the central part positively charged and the rear negatively charged. These observations are distinctly at variance with those of Schonland and in agreement with Simpson's breaking-drop theory. Afternoon thunderstorms of local origin, commonly known as 'heat thunderstorms' passed over the Observatory during September and early part of October 1929. Some of these were of the double or the multiple type, suggesting by the sequence of changes in the electric field that two or more thunderclouds

A NOR'WESTER SQUALL (2nd MAY—RAMPUR BOALIA, BENGAL).



Nor'westers are local thunderstorms which occur in south Bengal during the hot weather. They are accompanied by severe squalls which occasionally cause damage to life and property on land and on the rivers. The picture is a reproduction of the trace of a self-recording wind instrument. It shows how, with the sudden onset of the nor'wester, the wind rapidly increased from 20 to about 80 m.p.h. at about 6-15. p.m.

Plate III

of the unitary type passed in succession. It was observed also that the electric field of ordinary monsoon clouds, showing no lightning flashes, was predominantly negative. Among other investigations may be mentioned the recording of earth-currents at Alibag and some experiments on records of evaporation of water from small tanks.

17. *Alipore Observatory, Calcutta.*—The storm and heavy rain warnings and aviation forecasts from this observatory have already been described. As it was found that it would be superfluous to have observations from the close net-work of 60 auxiliary stations under schoolmasters during the non-nor'wester period, these were stopped from the 13th November 1929. The self-recording instruments put up at various stations in connection with the scheme of nor'wester study were, however, kept going. With effect from the 1st February 1930 all the activities in connection with the intensive study of weather in Bengal were resumed. As usual the Alipore Observatory remained responsible for the test, standardisation and issue to observatories of ordinary meteorological instruments. Amongst other important duties may be mentioned the determination of time by transit observations of stars and the wireless broadcasting of time signals at 14 and 22 hrs. I. S. T. This broadcast is done by means of a special machine which is set in motion at the correct time by pressing a key. The observatory is equipped with a Marconi receiver and the time signals of Bordeaux are received for checking the time determination of the observatory. It is gratifying to see from these various checks and comparisons that the time determination at the Alipore Observatory was maintained at a high degree of reliability.

18. *Madras Observatory.*—The Madras Daily Weather Report was published throughout the year. The supply of correct time to local shipping and, through the Indian Telegraph system, to the whole country was as usual one of the most important items of work during the year. Comparisons with wireless time signals broadcast from foreign stations, including Bordeaux and Rugby, were made daily as a check on the local time determination.

19. *Meteorological Office, Karachi.*—Owing to the inauguration of the regular Imperial Airways Air Mail Service in April and the prospect of trial flights of airships to Karachi, the year was marked by considerable activity at the Karachi Office. A programme for the supply of meteorological reports and forecasts for the section between Bushire and Karachi was prepared and distributed to all parties concerned. Except forecasts in plain language, all actual reports of landing ground and upper air data were issued to the pilots in code to avoid excessive wireless costs. The number of weather reports and forecasts issued to the Imperial Airways machines on this section of the route during the year was 679. The Indian State weekly airmail service between Karachi and Delhi started at the end of December 1929. 46 weather reports and forecasts were issued to the pilots for the Karachi-Jodhpur section of the route. The meteorological organisation of the Karachi Office was considerably improved by obtaining, (*a*) morning and evening reports from nearly 40 stations in north-west India, (*b*) 2, 6 and 12 G. M. T. synoptic weather

reports from Iraq through the Baghdad W/T station, (*c*) broadcasts from Abu Zabal containing morning synoptic weather data from Egypt, Sudan, Palestine and Syria, (*d*) reports from 4 new inland stations in Persia, and (*e*) daily afternoon pilot balloon observations from the three stations Bait-ul-Falaj, Bahrein and Gwadar. Two new third class observatories were also started at Naushahro and Badin in Sind in December 1929. The strength of the forecasting staff was increased by the addition of an Assistant Meteorologist.

The Karachi Office was also responsible for the administration of 23 observatories distributed over Persia, Arabia, Baluchistan and Sind, preparation of climatological tables for those stations, the issue of daily weather reports to local press for the section from the Persian Gulf to Sind and warnings of adverse weather to six local officers at Karachi. The first class weather observatory at the aerodrome at Drigh Road, 11 miles away from the main forecasting office, began the investigation of vertical temperature gradient over the first few hundred feet above ground; daily recording thermographs and unventilated resistance thermometers at the four heights 16, 56, 156 and 256 feet above ground were installed on the old wireless mast that had been erected two years ago, and a cage worked by a hand-winch was provided to carry observers up and down the mast to attend to the instruments daily. A summary of the meteorological conditions over the area, Persian Gulf to Sind was undertaken and the work was nearing completion towards the end of the year. The R. A. F. at Drigh Road continued their co-operation by collecting upper air temperature data during aeroplane flights. There were 141 such ascents during the year.

20. *Kodaikanal Observatory.*—The solar and astronomical researches of the Observatory during the calendar year 1929 have been summarised in the Annual Report of the Kodaikanal Observatory. In 1929 the sun has shown considerably less activity than in the previous year, the mean daily number of spots showing a decrease of 12 per cent. and the mean daily numbers and areas of prominences showing a decrease of 23 and 29 per cent. respectively. There was, however, a slight increase of 4 per cent. over the year 1928 in the case of prominences projected on the disc as absorption markings in hydrogen light. An eruptive prominence photographed on the 5th September 1929 reached a height of 567,000 km. above the chromosphere. Dr. Hale of the Mount Wilson Observatory offered the loan of a spectrohelioscope and asked the co-operation of this Observatory in a scheme for the study of the sun with this instrument. The offer has been accepted and co-operation promised.

The Director went on deputation to observe the total solar eclipse of 9th May 1929 at Pattani in Siam where he joined the expedition of the Joint Eclipse Committee of the Royal Society and Royal Astronomical Society. Observations of prominences, etc., were taken at Kodaikanal and cabled to Pattani on the 8th, in order to enable the expedition to be prepared for any possible limb phenomena. Though the weather was unfavourable, a complete series of spectroheliograms and photoheliograms and observations with Dobson's spectrograph were taken.

21. *Meteorological Office, Delhi.*—The forecasting centre at Delhi was started in the middle of November 1929, in a hired building at 19, Prithviraj Road. The Upper Air Observatory at Ambala and the surface observatory in the Central Telegraph Office, New Delhi, were shifted to this office. Two sets of weather charts were prepeared daily from morning and afternoon observations telegraphed daily from north-west Indian stations. The actual forecasting work began with the inauguration of the State Air Mail Service between Karachi and Delhi on the 29th December 1929.

22. *Meteorological Offices at Quetta and Peshawar for R. A. F.*—The R. A. F. Meteorologists at Quetta and Peshawar issued detailed local forecasts and warnings, each for his own immediate neighbourhood, as well as general accounts and forecasts of weather for the Delhi-Peshawar and Quetta-Karachi air routes. Special route forecasts were issued on about 250 occasions by Quetta and 225 occasions by Peshawar. The work of the first class observatories at Quetta and Peshawar was carried out, as usual, under the supervision of the Meteorological Officers. In order to enable the latter to devote more attention to investigational work, a graduate clerk was added to the staff at Quetta and Peshawar. The Meteorological Officer at Peshawar proceeded on leave on the 23rd March 1930 and a temporary Meteorologist from the India Meteorological Department was posted to Peshawar from the same date.

R. A. F. flying machines continued to obtain observations of pressure and temperature of the upper air at Peshawar, Quetta, Kohat and Risalpur. These data were made available to this department. There were 304 ascents under the supervision of the Meteorological Officer at Peshawar and 319 ascents under the supervision of the Meteorological Officer at Quetta during the year.

23. *Other Observatories.*—There were at the end of the year 229 second, third, fourth and fifth class observatories maintained by the department. The observatory at Lahore continued to function as a combined first class and pilot balloon station. Besides these there were 52 non-departmental observatories whose records were scrutinised by this department and in most cases utilised in the Daily Weather Reports and other departmental publications. The importance of these observatories need hardly be emphasised and the co-operation of the Indian States and public bodies for the furtherance of the study of Indian Meteorology is much appreciated.

Rainfall Registration.

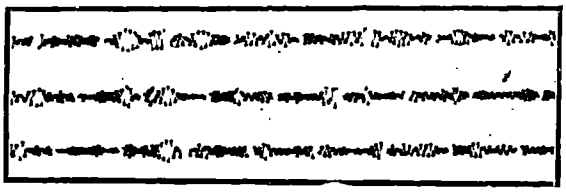
24. The system of provincial rainfall registration for which the Director-General of Observatories is the consulting authority continued its widespread work satisfactorily. The following table based on reports for 1929-30 shows the number of raingauges in each province and in the Indian States at the end of the year and the number of inspections of these during the year,

with corresponding figures for the preceding year for purposes of comparison :—

No.	Province.	Number of Raingauges at the end of		Number of Inspections.		Change.	Remarks.
		1929-30	1928-29	1929-30	1928-29		
1	Burma ..	214	215	211	214	—3	Satisfactory.
2	Assam ..	129	126	118	116	+2	Satisfactory.
3	Bengal ..	234	231	210	218	—8	Generally good.
4	Bihar and Orissa..	297	298	275	279	—4	Satisfactory.
5	United Provinces	269	269	239	224	+14	Generally good.
6	Punjab ..	154	154	121	128	—7	Generally good.
7	North-West Frontier Province.	33	31	28	28	0	Good.
8	Baluchistan ..	77	72	64	54	+10	Good.
9	Bombay ..	304	304	266	264	+2	Generally satisfactory.
9 (a)	Western India States.	27	27	1	2	—1	..
9 (b)	Baroda ..	13	13	7	8	—1	Good.
10	Rajputana ..	338	332	320	304	+16	Good.
11	Central India ..	198	198	157	154	+3	Satisfactory.
12	Jammu and Kashmir.	34	33	28	24	+4	Generally satisfactory.
13	Central Provinces	115	115	96	94	+2	Generally good.
13 (a)	Berar	42	42	39	40	—1	Generally good.
14	Hyderabad ..	17	17	17	17	0	..
15	Mysore ..	239	234	205	197	+8	Good.
16	Coorg	9	9	5	8	—3	Good.
17	Madras ..	510	503	483	482	+1	Good.
				Net change + 34			

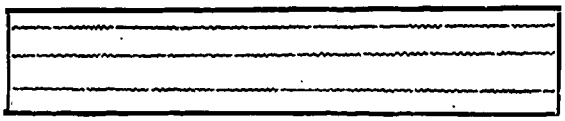
MICROSEISMS AT COLABA.

FIG. 1



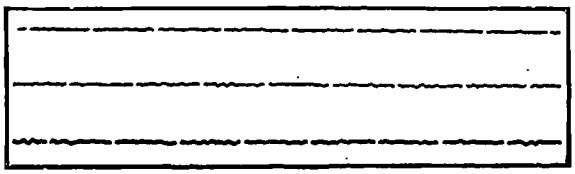
12-11-27 (early morning)

FIG. 2



9-7-29

FIG. 3



12-4-30 (afternoon)

The figures illustrate the different types of microseisms, recorded at Colaba Observatory, which are associated with disturbed weather in the Indian Seas. A strong wind produces big sea waves and thus causes a great disturbance of pressure over the bed of the ocean, and generates minute tremors which travel with a velocity of about two miles per second. The tremors are picked up by a highly sensitive seismograph under suitable adjustment. The interval between consecutive breaks in each line of the figures is equivalent to a minute of time.

FIG. 1. This type of microseisms is produced by storms in the Arabian Sea and the Bay of Bengal. They begin to make their appearance as soon as a storm has formed, increase in amplitude as the storm increases in intensity and comes towards Bombay, and disappear after it has passed inland and ceased to affect the sea. They are vibrations having periods of 4 to 6 seconds, and show characteristic irregular variations in amplitude, a feature which enables one to distinguish them readily from microseisms of other types. They are thus a useful aid to the meteorologist. The record given above is a portion from that obtained on Nov. 11-13, 1927, when a storm was raging in the Arabian Sea off the Konkan coast.

FIG 2. This type of microseisms is obtained during the south-west monsoon. They are more or less steady vibrations having periods of 4 to 10 seconds. They generally begin to make their appearance early in May with the advance of the monsoon in the south-east Arabian Sea and increase in intensity as the monsoon current approaches towards Bombay. They continue strongly pronounced so long as there is a vigorous monsoon over the Indian Seas, but weaken as soon as the current becomes weak, and disappear when the monsoon retreats from the Indian Seas.

FIG. 3. This type of microseisms is produced by local disturbed weather, such as pronounced land and sea breezes. They have periods varying from 10 to 30 seconds, i. e. the vibrations are longer than those of the preceding types.

Heavy Rainfall Reports.—Heavy rainfall is often so very local that small unrepresented areas can have as much as 10″ without the Daily Weather chart conveying the least suggestion of the local inundations. In order that such useful data might be promptly available for the Daily Weather Report it was arranged in 1921 that reports of 5″ or more of rainfall at the Provincial raingauge stations should be telegraphed to the forecasting centres. The number of such telegrams received during 1929-30 was 248 as compared with 256 in the previous year.

Snowfall Registration.—Information as to the amount of distribution and time of occurrence of snowfall in the Himalayas and the Afghan mountain areas was on the whole tolerably complete, and the thanks of the department are due to the various officers who collected and forwarded the reports.

CONCLUDING REMARKS.

25. The Meteorological Department owes a large part of its usefulness to the sympathetic assistance it receives from other departments. Civil Surgeons and other officers of Government Departments help the meteorological work as honorary superintendents of observatories and in other capacities. The Posts and Telegraphs Department assists this department in the rapid transmission of meteorological information; at the same time they allow their employees to act as observers.

Weekly telegrams are received from April to October from the Director, Royal Alfred Observatory, Mauritius, and from the departmental observatories at Zanzibar and Seychelles. These telegrams give valuable information of the weather conditions in the Indian Ocean, and the department is indebted to these observatories for the punctual transmission of the information.

The department is greatly indebted for important information on meteorological conditions prevailing before and during the south-west monsoon to the Controller, Physical Department, Cairo; the Directors of the observatories at Buenos Ayres, Santiago, and Batavia; the Astronomer Royal, Cape Town; Director L'Observatoire Physique Central, Leningrad; the Secretary, Friends' Industrial Mission, Banani Pemba, Zanzibar; the Principal Medical Officer, Tanganyika Territory, Dar-es-Salam; the Commonwealth Meteorologist, Melbourne; Director of Agriculture, Salisbury, Rhodesia; Chief of the Weather Bureau, Washington and the Director, Koninklijk Magnetisch and Meteorologisch Observatorium, Batavia, Java.

Thanks are due to the Marine Superintendents of the British India Steam Navigation Company, the Scindia Steam Navigation Company and the Asiatic Steam Navigation Company, for having agreed to instruct the captains of their fleets to send weather logs to this department direct. Captain Whish, Port Officer, Bombay, and Commander Norcock, Deputy Conservator of the Port of Calcutta, have been willing helpers of this department from time to time, for which the department is grateful to them.

The department is indebted to His Exalted Highness the Nizam of Hyderabad for the help rendered by his State in connection with sounding and pilot balloon work at the Nizamiah Observatory at Hyderabad and to the Governments of Mysore and Travancore for their assistance in the regular collection of pilot balloon data at Bangalore and Trivandrum respectively.

Thanks are also due to the Eastern Telegraph Company for charging this department half the usual rates for the transmission of S. American weather telegrams. Thanks are also due to the various pilots of the Imperial Airways Ltd. for the supply of weather logs to this department. These logs contain the actual weather experienced by the pilots during the flights for which forecasts were issued by the meteorological offices at Karachi and Delhi and, besides helping to verify the forecasts, afford valuable data for the study of flying weather.

Before the publication of this report the Hon'ble Sir Bhupendranath Mitra completed his term of membership of the Viceroy's Executive Council. The expansion of this department in recent years is, to a great extent, due to his sympathetic interest and I cannot conclude this report without expressing the deep sense of gratitude of the department to him.

POONA :

The 28th August 1930.

C. W. B. NORMAND,

Director-General of Observatories.

APPENDIX A.

THE STAFF OF THE INDIA METEOROLOGICAL DEPARTMENT AS IT STOOD ON 31ST MARCH 1930.

METEOROLOGICAL OFFICE, POONA.

Director-General of Observatories.

C. W. B. Normand, M.A., D. Sc. (Edin.)

General Section.

Meteorologist	.. V. V. Sohoni, B.A., B. Sc. (Bombay).
Assistant Meteorologist ..	.. L. A. Ramdas, M.A., Ph. D. (Calcutta).
Superintendent	.. Shamsul Haq, Khan Sahib.
Assistants	.. 5.
Stenographers	.. 2.
Clerks and typists	.. 9.
Clerks (temporary)	.. 4.

Weather Section.

Meteorologist	.. K. J. Kabraji, M. Sc. Ph. D. (London).
Assistant Meteorologists ..	.. B. N. Desai, M. Sc. (Bombay), Ph., D. (Edin.), B.A., LL. B. (Bombay). A. K., Das, M. Sc. (Calcutta), D. Sc. (Paris).
Assistants	.. 2.
Clerks and tabulators	.. 14.
Draftsmen	.. 5.

Observatories Section.

Meteorologist	.. S. Basu, M. Sc. (Allahabad).
Assistant	.. 1.
Clerks	.. 3.

Marine Section.

Meteorologist	.. S. Basu, M. Sc. (Allahabad).
Assistant	.. 1.
Clerk	.. 1.
Draftsman	.. 1.

Instruments Section.

Meteorologist	.. J. M. Sil, B.A. (Calcutta), B. Sc. (Engg.) (Boston Tech.)
Assistant	.. 1.
Inspector of Observatories ..	.. 1.
Clerk	.. 1.
Observers (temporary) ..	.. 2.
Store-keeper (temporary) ..	.. 1.
Mechanics (temporary)	.. 2.
Skilled Mistri (temporary) ..	.. 1.
Overseer (clerk of works) (temporary)	.. 1.

Upper Air Section.

Meteorologist	K. R. Ramanathan, M.A., D. Sc. (Madras.)
Assistant Meteorologist	Barkat Ali, B.A., M. Sc. (Punjab).
Assistants	2.
Clerks	2.
Upper Air Observers	2.
Clerk (temporary)	1.

Library Section.

Meteorologist	S. R. Savur, M.A. (Madras), Ph.D. (London).
Assistant Meteorologist	M. V. Unakar, Rao Saheb, B.A. (Bombay) (on leave).
Assistants	2.
Librarian	1.
Clerks	5.
Draftsman	1.

Climatology Section.

Meteorologist	S. R. Savur, M.A. (Madras), Ph.D. (London.)
Assistant Meteorologist	V. Venkata Subbu, M.A., B.L. (Madras) (officiating).
Assistant	1 (vacant).
Clerks	9.
Temporary clerk	1.
	S. K. Pramanik, M.Sc. (Lucknow), Ph.D. (London), D. I. C. (London). (Meteorologist designate for Rangoon).

UPPER AIR OBSERVATORY, AGRA.

Meteorologist-in-charge	G. Chatterjee, M. Sc. (Calcutta).
Meteorologist	N. K. Sur, D. Sc. (Allahabad).
Assistant Meteorologists	B. N. Sreenivasiah, M. Sc. (Calcutta). D. M. Patel, B. Sc. (London), A. R. C. S.
Superintendent	C. P. Venkatarama Aiyer, M.A. (Madras).
Mechanical Assistant	Chainsukh.
Clerks or Observers	34.
Clerks or Observers (out-station staff)	50.
Mechanics (temporary)	10.
Clerks and Observers (temporary for unlimited period)	11.
Clerks and Observers (temporary for limited period).	2.

COLABA AND ALIBAG OBSERVATORIES, BOMBAY.

Meteorologist	.. S. K. Banerji, M. Sc., D. Sc. (Calcutta).
At Colaba.	
Head Clerk	.. N. Chatterjee, M. Sc. (Calcutta).
Observers	.. 6.
Cashier	.. 1.
Marine Clerk	.. 1.
Typist and Stenographer ..	.. 1.
At Alibag.	
Observers	.. 2.

ALIPORE OBSERVATORY, CALCUTTA.

Meteorologist	.. S. N. Sen, M. Sc. (Calcutta and London), Ph.D. (London).
Assistant Meteorologists ..	.. M. G. Subrahmanyam, B.A. (Madras), LL. B. (Bombay).
	V. Doraiswamy Iyer, B.A. (Madras).
Superintendent	.. S. C. Ghosh, Rai Saheb (on leave). K. P. Banerji, M.A. (officiating).
Chief Observer	.. G. N. Mukherji (officiating).
Clerks (upper division)	.. 5.
Clerks (lower division) ..	.. 19.
Stenographer	.. 1.
Draftsmen	.. 3.
Observers	.. 4.
Inspectors	.. 2. } Temporary for nor'wester study
Clerks and Observers	.. 9. } scheme.

METEOROLOGICAL OFFICE AND MADRAS OBSERVATORY.

Assistant Meteorologist ..	.. A. A. Narayana Ayyar, B.A.
Time Assistant	.. 1.
Weather Assistant	.. 1.
Clerks	.. 4.
Observers	.. 3.
Printer	.. 1.

METEOROLOGICAL OFFICE, KARACHI.

Meteorologist	.. B. N. Banerji, M. Sc. (Allahabad). Ph.D. (Cantab).
Assistant Meteorologists ..	.. P. R. Krishna Rao, B. Sc. (Mysore). K. Das, M. Sc. (Punjab), Ph.D. (London.)
Chief Observer	.. 1.
Head Clerk	.. 1.
Inspector of Observatories ..	.. 1.
Steno-typist	.. 1.
Clerks or Observers	..11.
Clerks or Observers (temporary)	.. 5.

SOLAR PHYSICS OBSERVATORY, KODAIKANAL.

Director	.. T. Royds, D. Sc. (on leave for 5 months and 9 days from 11th November 1929).
Assistant Director	.. A. L. Narayan, M.A., D. Sc. (Officiating Director).
Assistants	.. 3.
Recorders	.. 4.
Mechanic	.. 1.
Book-binders	.. 2.

METEOROLOGICAL OFFICE, DELHI.

Meteorologist	.. S. C. Roy, M. Sc. (Calcutta), D. Sc. (London).
Professional Assistant	.. B. K. Roy, M. Sc. (Calcutta).
Inspector of Observatories ..	.. 1.
Clerks	.. 5.
Observers	.. 3.

METEOROLOGICAL OFFICE, No. 3 (INDIAN) WING, R. A. F., QUETTA.

Meteorologist	.. Flight Lieutenant R. P. Batty.
Senior Clerk	.. 1.
Junior Clerks and Observers ..	.. 3.

METEOROLOGICAL OFFICE, No. 1 (INDIAN) GROUP HEADQUARTERS, R. A. F., PESHAWAR.

Meteorologist (temporary) ..	.. A. K. Roy, B. Sc. (Calcutta), B.A., (Oxon.) *vice* Fl./Lt. Veryard (on leave).
Senior Clerk	.. 1.
Junior Clerks and Observers ..	.. 3.

APPENDIX B.

PUBLICATIONS.

The following departmental publications were issued or were in press during the year :—

I. *Periodical—*

1. Indian Daily Weather Report.
2. Weekly Weather Report.
3. Monthly Weather Report.
4. Annual Supplement to the Daily Weather Report.
5. India Weather Review (Annual Summary) issued in seven parts (Volume for 1928) :—
   - (*a*) Part A.—Summary of Weather and Rainfall.
   - (*b*) Part B.—Snowfall.
   - (*c*) Part C.—Storms and Depressions.
   - (*d*) Part D.—Annual Tables.
   - (*e*) Part E.—Seismic Records.
   - (*f*) Part F.—Errata to Monthly Weather Report.
   - (*g*) Part G.—Introduction.
6. Daily Rainfall of India (Volume for 1926).
7. Monthly Rainfall of India (Volume for 1926).
8. Report on the Administration of the Meteorological Department of the Government of India in 1928-29.
9. Memorandum on the probable character of the weather in North-west India in January, February and March (for 1930).
10. Memorandum regarding the probable amount of Monsoon rainfall (for 1929).
11. Memorandum on the rainfall of June, July and the probable amount during August and September (for 1929).
12. Statement of the rainfall and snowfall of north-west India in January, February and March and a comparison of the seasonal forecast with the actual precipitation (for 1929).
13. Statement of the actual rainfall in June, July, August and September and a comparison of the forecasts with the actual rainfall (for 1929).
14. Kodaikanal Observatory Bulletins (for 1929).
15. Annual Report of the Kodaikanal Observatory (for 1929).
16. Calcutta Daily Weather Report.
17. Madras Daily Weather Report.
18. Upper Air data Parts 1—14 (for 1928).
19. Magnetic, meteorological and seismological observations made at the Government Observatory, Bombay. (Volumes for 1924 and 1925).

II. *Occasional—*

1. The Rainfall Organisation Circular.
2. Note on the functions, organisation and present developments of the India Meteorological Department.
3. Cloud Atlas for the use of the Observers of the India Meteorological Department.
4. Relative Humidity Tables.
5. Karachi Broadcast Code.
6. Weather Message Code (1929).

III. *Memoirs of the India Meteorological Department—*

Volume XXV—

Part III.—Data of Heavy Rainfall over short periods in India—Departmental.

Part IV.—Correlation between weather and crops with special reference to Punjab wheat. By Rao Saheb Mukund V. Unakar.

IV. *Scientific Notes—*

Volume I—

No. 4.—On Temperature of Exposed Rails at Agra. By K. R. Ramanathan.

No. 5.—Frequency of Thunderstorms in India—Departmental.

No. 6.—Correlations between Pre-monsoon conditions over north-west India and subsequent monsoon rainfall over north-west India and Peninsula.—By Rao Saheb Mukund V. Unakar.

V. The following were in press at the end of the year—

Memoirs of the India Meteorological Department :—

Volume XXV—

Part V.—Discussion of results of sounding balloon ascents at Agra during the period July 1925 to March 1928 and some allied questions.—By K. R. Ramanathan.

Part VI.—The wind at Agra and its structure.—By Barkat Ali.

Scientific Notes—

Volume I—

No. 7.—Monthly normal upper winds over eight stations in India—Departmental.

No. 8.—Monthly normal isobars upto 3 km. over India and adjacent regions with wind roses at selected stations—Departmental.

No. 9.—Comparison of temperature in Stevenson screens at heights of 6 ft., 4 ft. and 2 ft. above ground.—By K. R. Ramanathan.

No. 10.—Distribution of temperature in the lower stratosphere.—By P. R. Krishna Rao.

Volume II—

No. 11.—Comparative observations of temperature in white-painted, unpainted and black-painted Stevenson screens.—By Barkat Ali.

No. 12.—Association of mid-monsoon Indian Rainfall with pressure distribution over the globe.—By Rao Saheb Mukund V. Unakar.

No. 13.—Atmospheric instability at Agra associated with a western disturbance.—By K. R. Ramanathan.

No. 14.—Horizontal atmospheric visibility at Agra.—By Barkat Ali.

No. 15.—Winds in higher levels over Agra.—By N. K. Sur.

VI. The following papers or notes were also contributed to other journals :—

By S. K. Banerji—

The effect of the Indian mountain ranges on the configuration of the isobars—Indian Journal of Physics, Volume VI, Part VI, pages—477-502.

By G. Chatterjee and S. C. Roy—

Origin of nor'westers—Nature Volume 124, 1929, page 481.

Probable origin of the cold wave in India, February 1929. Natu e Volume 124, 1929, page 579.

By G. Chatterjee—

Balloons for Upper Air Work—Nature, Volume 124, 1929, page 793.

An upper air temperature indicator for use with pilot balloon—Gerland's Beitr. Z. Geophysik Volume 24, 1929, pages 343—352.

By G. Chatterjee and S. C. Chakravarty—

Eine Einfache Abwurfvorrichtung für Ballon—Meteorographen aus bestimmter Höhe—Met. Zts. Bd. 47, 1930, pages 118—119.

By V. V. Sohoni—

Meteorological Normals of Calcutta—Journal and Proceedings of the Asiatic Society, Bengal, (New Series, XXV. 1929, No. 1, Issued March 1930).

By K. R. Ramanathan—

Distribution of temperature in the first 25 km. over the earth—Nature, 1929, Volume 123, page 834.

Distribution of potential temperature in the first 25 km., over the Northern Hemisphere—Nature, 1929, Volume 124, page 509.

By S. C. Roy, and A. K. Roy—

Structure and movement of cyclones in the Indian seas—Beitr. Z. Phy. d. Fr. Atmosphäre Bd. 16, 1930, page 224.

By A. L. Narayan, (with A. S. Rao)—

Further regularities in the spectrum of doubly-ionised Arsenic—Nature, 1929, Volume 124, page 229; and Zeitschrift Für Physik Bd. 57, 1929, pages 865—838.

On the series spectrum of doubly ionised lead. Nature 1929, Volume 124, page 794; and Zeitschrift Für Physik, Bd. 59, 1929, pages 687—689.

On the structure of the trebly ionised spectrum of lead. Communicated to Zeitschrift Für Physik in December 1929.

By Rao Saheb M. V. Unakar—

Sunspots and Pressure—Nature, Volume 124, 1929, page 11.

March rainfall of north-west India and Agra upper winds in December—January Nature, Volume 124, 1929, page 618.

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Chief Features of the Year.

For some years past the department has been expanding concurrently with the opening of Indian air-routes. In the year under review the schemes connected with aviation reached a stage of completion, at which it was thought they would remain for some time without any further considerable expansion and so enable the department to consolidate its organisation and to settle down to a programme of practical and scientific work, preparatory to further development. Simultaneously however the period of financial stringency that has overtaken India began to be noticeable. Other schemes, unconnected with aviation, but aiming to introduce uniformity and increased efficiency into the departmental organisation had to be shelved, such, for instance, as the projects to raise the remaining observatories in south India to the same status as those throughout northern India and Burma and to give the Headquarters Office at Poona the benefit of the recent developments by arranging for the preparation of an evening weather chart there. Considering that most other countries prepared weather charts three times daily, even before the 1914-18 War, the proposal to arrange for a second daily weather chart at Poona could not be considered extravagant. It is now feared that the stage reached towards the end of the year under review may prove to be not one of merely temporarily arrested development but a climax, beyond which the next stages may perhaps be the retracing of steps recently taken.

2. While the immediate cause of the recent developments was the need to meet the requirements of aviators on the Karachi-Rangoon air-route, who want detailed and up-to-date weather information about upper winds, clouds, visibility, thunderstorms, duststorms, etc., it is not possible to draw any exact line beyond which it may be said that the work done is done solely on behalf of civil aviation and not for other purposes. The general basis of the meteorological organisation, namely, the receipt of weather telegrams at a few forecasting centres from a network of observatories, has been strengthened; and more information is

now available at these centres both about weather near ground level and about the winds aloft; and is of use not only to aviators but also in the preparation of general weather forecasts, storm and heavy rainfall warnings as well as in the investigation of improvements in seasonal forecasting and of the causes of past weather. Part of the development was accomplished in the previous two years and the last stage, except for permanent building schemes, was reached in the early months of 1931, when the arrangements for the Delhi-Calcutta and the Calcutta-Rangoon routes were nearly completed. The gazetted staff for the Delhi Office, which was started last year with the help of one of the reserve meteorologists, and for the new Rangoon Office was recruited. Many observatories were raised from third to second class status, others were newly started, and special stations in the chain of observatories along air-routes were equipped with self-recording instruments. The regional forecasting centres at Calcutta and Rangoon, like those already established at Karachi and Delhi, began to prepare two weather charts a day, one for the usual 8 hrs. observations and the other for the newly introduced 17 hrs. observations, from a net-work of second class observatories in India, excluding the Peninsula. The Rangoon Office was opened in September 1930 and commenced functioning as a forecasting centre a little later. Steps were taken for the acquisition of some buildings and property near the aerodrome at Dum Dum, Calcutta, to locate a subsidiary weather service centre with a Professional Assistant in charge, under the control of the Meteorologist, Calcutta. Provision was also made for a similar centre at Akyab under the control of the Rangoon Office. A few new pilot balloon stations were opened and before the close of the year about 25 stations out of a total of 31 over the country had started to observe regularly an afternoon balloon flight in addition to the usual daily morning flight. This expansion of pilot balloon stations created a largely increased demand for hydrogen and much additional administrative and technical work at Agra Observatory, where special arrangements had to be made to cope with the increase. To complete the meteorological organisation under the sanctioned aviation schemes the main outstanding items are the erection of offices and residential quarters alongside the aerodromes at Karachi, Delhi and Rangoon. These constructions are part of the original plan but have to be deferred until a financially more propitious time arrives, although their value is undoubted, because they would lead to more direct personal touch with aviators and hence to increased efficiency.

With the spread of private flying in India the department has from time to time been called upon to help aviators in a way which is not directly connected with the working of the meteorological organisation. For example, candidates for pilot's licences require to be trained and examined in meteorology as a part of their course, and this department has adopted the policy of providing facilities at forecasting centres for the training and examination by local meteorologists of such candidates.

3. Mention must be made of the deplorable tragedy to the R. 101. The Karachi Meteorological Office had undertaken responsibility for the supply of weather forecasts and warnings to the airship on her incoming and return flights over the Persian Gulf and Mekran section. Special arrangements were made for the discharge of these duties; the forecasting centre was transferred from Karachi to the Airship Base observa-

tory at Drigh Road; a temporary telegraph office was opened there; the meteorological staff was strengthened by the deputation of an extra officer from Poona; a continuous 24 hour weather watch was put into operation a couple of days before the airship left Cardington; and weather charts were prepared twice daily (to be increased to 4 times daily) for the whole area lying between Ismailia and Karachi. All arrangements were running smoothly, and enthusiasm in all ranks was high, only to be suddenly quenched when the lamentable news reached Karachi of the disastrous dive of the airship against a hill near Beauvais in France on the 4th October.

4. An important scheme with which considerable headway was made during the year concerned the opening of a branch of agricultural meteorology. The scheme may be said to owe its origin to the Report of the Royal Commission on Agriculture 1928, and was elaborated by the department in consultation with a few agricultural experts. It proposed the creation of a temporary branch of agricultural meteorology to study the subject statistically and experimentally. About statistical studies it may be observed that if satisfactory correlation between weather conditions and crop yield and crop areas can be established, crop forecasting and the final estimates of production will be improved. Since there is no better deterrent to uncontrolled speculation in agricultural commodities than a good supply of agricultural statistics, and, since the cultivator eventually gains by all improvements in marketing, he stands to benefit in the long run from results of investigations on such subjects. As regards the experimental and biological parts, the proposal was made under two heads—routine and research. Under routine comes the standardisation of the meteorological and physical data collected at experimental farms. Under research the proposal aimed at selecting and standardizing the best methods for the measurement of radiation, evaporation, soil temperature, etc. Soil temperature, ultra-violet radiation and other kinds of radiation, the amount and quality of sunlight, the temperature of the leaves and stems of the plants, the wind forces on the plants are all, as one can readily conceive, phenomena which a research worker may want to know, when correlating the results obtained on experimental farms. In other words the aim is to be able to specify the local weather and climate of each crop, or, as some modern workers now call it, the micro-climate of each crop. The employment of two agricultural meteorologists and subordinate staff is contemplated for a period primarily of 5 years, involving an annual recurring expenditure of about Rs. 40,000. The proposal was placed before the Imperial Council of Agricultural Research, who agreed to give the grant that was required. It is intended that the officers, when appointed, should be in constant touch with agriculturists and meteorologists and be able to give advice in course of time to the agriculturist about meteorology and to the Meteorological Department about types of forecasting that could profitably be undertaken on behalf of agriculture.

5. A much smaller yet interesting scheme that was sanctioned during the year was the grant of two scholarships for post-graduate students to work on meteorological problems. Each scholarship, of Rs. 100 a month, is tenable for one year but renewable for a second year in suitable cases. For the present, the scheme is of a temporary nature and a further report is to be made on its working after two years' experience. In addition to

these regular scholars, it may be mentioned that officers of the department undertake, from time to time, to guide post-graduate students of universities in the study of meteorological problems for university degree theses. A few such workers were under training during the year.

6. On the scientific side of the department's work also there were some noteworthy items of progress. Soundings of the free atmosphere by balloons carrying self-recording instruments were made at Poona and Agra and also at the Nizamiah Observatory at Hyderabad (Dn.) with the co-operation of the Director there. Observations of upper air temperatures and humidities obtained from ascents of the Royal Air Force aeroplanes at Quetta, Peshawar and Karachi were studied. At Agra some innovations were introduced in the design of the Dines meteorographs. The original instrument gives a record which, for short ascents, is too small to be of practical value. A new type of instrument was evolved with more open scale for temperature and pressure and it is possible with its aid to explore in detail the lower layers of the atmosphere, by means of " Clown " balloons which release the instruments at pre-determined heights. A new temperature indicator was designed, which can be used to determine four successively different diminishing temperatures, when let off with hydrogen-filled balloons. Assistance was given as in former years to Professor Mehta for his researches on the transport of the spores of cereals' rust by upper winds. At Bombay, research was carried on on evaporation, on the electric field of overhead thunder clouds, on the electricity of monsoon rain and on the relationships between microseisms and the development and movement of storms over the Indian seas. A variety of subjects were investigated at Poona. The most interesting among them were the studies of the physical structure of individual storms, night radiation, atmospheric electricity, the sea breeze reaching Poona from the Bombay coast, local thunderstorms, the upper air circulation at cirrus level as well as studies regarding the possibility of improving seasonal forecasting formulæ in correlation coefficients. At Karachi, temperature investigations on the airship mooring mast were handicapped to a certain extent on account of defects in the special instrumental equipment, but ordinary thermographs at various heights were kept working and the data thus collected were subjected to a preliminary analysis; while at Kodaikanal, routine and research in solar physics were continued on lines of which a description has already been printed in that Observatory's Annual Report for the year 1930. The collection of data for an intensive study of weather in north-east India, particularly of the origin and mechanism of nor'-westers, was partially suspended during the year, except for the maintenance of self-recording instruments at a few stations, but the preparation of a preliminary report on nor'-westers based on the data accumulated so far was taken in hand. Appendix B shows the papers or notes by departmental officers that were published or were in press.

Marine Meteorology—Storm Warnings.

7. *The system of storm warnings for ports and shipping.*—Warnings for the approach of cyclonic storms or of bad weather were issued as usual from Poona and Calcutta to ports and shipping in the Arabian Sea and the Bay of Bengal respectively. According to the code of storm warning signals prevalent for many years past, the hoisting of a black

ball at the " extended " ports round the Bay of Bengal which exhibit locality signals of disturbed weather indicated " fair weather ". This was open to objection inasmuch as its meaning was the reverse of that of a ball in the current international storm signal system, where a ball means " atmospheric disturbance, be alert and look-out for further information ". Views of shipping interests and port authorities were taken and the black ball as a signal of fair weather at the Indian ports was abolished. The number of ports in the warning list was 37 on the west coast of India and 28 on the Bay of Bengal. In addition to the sea ports there were 8 river ports, 17 river police stations and 45 district police stations on the Calcutta warning list. The latest weather information was supplied as usual to shipping at sea by means of weather bulletins broadcast twice daily from coastal radio stations. In addition to these regular broadcasts, if the weather situation demanded it, bulletins were issued, as many as six times a day. The total number of weather bulletins and warning messages issued during the year was 9,712.

8. *Services to ports around the Bay of Bengal.*—Warnings were issued for 49 periods of disturbed or suspicious weather. On eight occasions the disturbances developed into storms, one of which was very severe. This occurred in November 1930, preceded by a period of unsettled weather, to the east of Ceylon. A depression formed in the south of the Bay on the 27th which intensified rapidly into a severe storm. On the morning of the 28th, its centre lay near latitude 10½°N., longitude 82½°E. Taking a northwesterly course, the storm crossed the Coromandel coast on the 29th morning between Cuddalore and Madras. It weakened during its passage westward across the Peninsula but caused some unsettled weather in the south-east Arabian Sea, off Malabar after the 30th. During its approach and passage very strong winds caused considerable damage to telegraph lines near the south Coromandel coast. There was also very heavy local rain in south Madras ranging from 5 to 12 inches in a day. This heavy rain caused breaches in the railway lines and much damage to crops and property in south-east Madras. The usual circular letters were issued to 28 Port Officers asking for opinions regarding the warnings issued to them during the year. All those who replied expressed satisfaction with the warnings received by them and had no suggestions or criticisms to offer.

9. *Services to Arabian Sea-ports.*—Warnings for disturbed or squally weather were issued on 15 occasions. The most important of these was during a storm which formed off the Coromandel coast in October. The storm originated in the Bay but moving westward crossed the coast near Negapatam on the 24th and passed into the Arabian Sea during the next two days as a depression. Once in the Arabian Sea it again gathered strength and became a storm on the 27th with centre near latitude 14½°N., longitude 71°E. The storm took a northerly course and ultimately passed inland just north of Surat at about 10 P.M., on the 29th. During its northward passage in the Arabian Sea, gales and squalls were experienced on and off the west coast right up to Surat. Some very very heavy falls of rain occurred in south India, the most outstanding ones being 16 inches at Negapatam on the 22nd and 13 inches at Trichinopoly on the 23rd. This heavy rain in south Madras, especially in the Nilgiris, caused severe flooding in many places leading to dislocation of

railway traffic, loss of property, damage to standing crops and also some loss of life. Seventeen Port Officers sent their annual returns about the warnings sent to them; all of them said that the warnings were timely and satisfactory and that no change in the present system is necessary.

10. *Exchange of information with ships at sea.*—The chief sources of marine data are wireless weather messages from ships at sea and extracts from weather logs of ships calling at the principal ports on the Indian seaboard. The object of the system of radio messages from ships is to attain greater efficiency in cyclone-warning work. It was started in 1914, suspended during the War and resumed in 1921. Since that year there has been a steady increase in the use of this system by ships in Indian waters. The number of ships' messages from the Bay and the Arabian Sea during the year totalled 5,869 (from the Bay 4,491 and from the Arabian Sea 1,378) in comparison with 4,635 in the previous year, 4,342 in 1928-29, 3,689 in 1925-26 and 956 in 1921-22. It is not possible to name here every steamship that rendered help in this direction, but given below is a list of those ships which sent more than 40 weather messages during the year along with the numbers of messages sent by each:—

Angora	94	Ethiopia	108
Arankola	130	Garbeta	60
Aronda	72	Havildar	46
Aungban	209	Hosang	59
Badarpur	169	Jalapalaka	72
Barpeta	120	Jalavira	55
Baymay	122	Maharaja	87
Binfield	58	Masimpur	44
Chakrata	61	Meerkerk	59
Chantala	102	Nawab	77
Chilka	112	Pasha	56
Cocanada	59	Rajula	138
Dara	70	Rohna	48
Egra	136	Schiekerk	60
Ekma	75	Singu	134
Elephanta	41	Tairea	65
Erinpura	59	Varsova	44

This is certainly a most gratifying increase indicating as it does growing willingness on the part of the ships' officers to co-operate with weather services ashore; but even so forecasting officers occasionally lack, at critical times, ships' observations from the vicinity of the centre of a disturbance at sea and find themselves compelled to draw their inferences from and base their broadcast messages to ships on coastal observations alone. Such situations are more particularly experienced in regard to the Arabian Sea, which, not being land-locked like the Bay of Bengal, makes the forecaster wish for more observations from steamers there. It may be that sometimes it happens that storm centres develop in ocean areas far from the normal shipping routes, that is, in areas where there are few, if any, ships to send reports. Possibly also commanders of ships with the aid of the wireless weather reports are now better able to avoid storm areas. Despite these facts it is felt that improvement in the system is still possible, and it would be most helpful if co-operating captains could induce others to take a share in this organisation of

supplying information from sea. A message, which may appear to be colourless by itself, is frequently of great use, when considered along with other observations plotted on a chart. There is a great future for synoptic meteorology at sea; but still more extensive co-operation between the sailor and the meteorologist is needed to make full use of the great aid of wireless weather reports to navigation and safety of life at sea.

11. The second important source of data for later study is the log extracts collected by the marine clerks in Calcutta and Bombay and other agencies mentioned below. The old log form was replaced by two new forms—one for use during ordinary weather and the other during disturbed weather. These forms were designed to secure the collection of fuller marine data on a more elaborate scale, and the British India Steam Navigation Company, the Scindia Steam Navigation Company and the Asiatic Steam Navigation Company continued the arrangements with their ships' captains to copy and despatch such logs to this department direct. The Port authorities at Rangoon also continued to render help by allowing the observers of the Time Ball and Tidal Observatory of the Port Commissioners to collect ships' data. Occasionally in special cases logs of steamers with experience of disturbed weather were collected at Madras; and the Colombo Port authorities also helped this department similarly whenever requested. A total of over 4,600 logs was recorded at the end of the year. The policy of lending meteorological instruments to ships was pursued slowly but steadily. During the year under review three more ships were added to the list of those supplied with meteorological instruments, thus bringing their number to 19. The weather logs from the captains of these 19 steamers were received regularly.

Inland weather warnings and forecasts.

12. *Heavy rainfall warnings.*—The majority of the officers to whom warnings of heavy rain on land are issued from Poona and Calcutta were district officers and officers of the Irrigation, Railway and other departments. The number of officers on the warning list was 239 officers including 28 officers of the Telegraph Department who generally required warnings for strong winds. This is a slight decrease, compared with the previous year for which the corresponding figures were 263 and 31. This decrease is attributable to the fact that a number of former recipients of warnings have enrolled themselves as subscribers to the Daily Weather Telegraphic Summary, which contains heavy rainfall forecasts, and have removed their names from the list of special warnings. The system worked satisfactorily throughout the year; the forecast and warning messages issued from forecasting centres number 5,746, while 1,118 telegrams of heavy rainfall reports were sent direct to various officers by local meteorological observers. Reports on the working of the warning system were received from 107 officers who have expressed satisfaction with the warnings issued; the few suggestions or criticisms that were received were all on minor points. The following extracts from reports of officers may be of some interest.

From the Executive Engineer, Karnal Division:—

"Warnings received from the Meteorological Department, Poona, during 1930 monsoon proved distinctly satisfactory. There were no floods in the river of any magnitude with the exception of one (on 27th July 1930) the warnings of which had already been received and the forecast amply fulfilled."

From the Superintending Engineer, Northern Circle, Bombay:—

"Warnings for floods and storms sent by telegram during the last year were promptly received by the Executive Engineers in the circle and were considered very useful."

The Executive Engineer, Nellore Division:—

"There were severe floods due to heavy rain in Nellore District and the staff in the mofussil were warned in advance to be on the alert."

The Engineer-in-Chief, Calcutta-Chord Railway, to the Meteorologist, Calcutta, dated 4th July 1930:—

"Your kind help has contributed to the success of the operations (on the Bally bridge) to a large extent and I am most grateful to you and your staff for the assistance you have given me."

13. *Aviation forecasts.*—With the extension of the State Air Mail services from Karachi to Delhi and later on with the inauguration of the French and Dutch Air-Mail Services, the forecasting centres at Karachi, Delhi, Calcutta and Rangoon supplied an increasing amount of information to fliers. In addition to the regular air mail services there was an appreciable number of forecasts issued to private fliers. The total number of aviation forecasts issued was about 1,750 out of which Karachi was responsible for about 800, Delhi for 400 and Calcutta for over 100, Quetta and Peshawar for over 300.

Offices and Observatories.

14. A list of the staff of the India Meteorological Department as it stood on the last day of the year under review is given in Appendix A. The second and revised edition of the note on "Functions and Organisation of the India Meteorological Department" was published by the Department of Industries and Labour in February 1931. This contains a general description of the organisation and duties of each office. In July (1930), which is the anniversary month of the opening of the department's headquarters at Poona, was held the third annual conference of departmental officers. It considered and made recommendations upon questions such as the training of air pilots in meteorology, aviation forecasting arrangements, broadcasting observations from shore stations for the benefit of ships at sea, remodelling of codes in order to fall in line as closely as possible with international practices and other administrative matters.

15. *Headquarters Office, Poona.*—The main lines of scientific work have already been mentioned amongst the chief features at the beginning of this report. A helpful means of maintaining interest on the scientific side is the colloquium, of which 21 meetings were held, the discussion at each meeting being opened by a member of the staff who took as his subject either his own original work or a recent important paper published in a foreign journal. The Director-General (Dr. Normand) was the President of the Physics Section of the Indian Science Congress held in January 1931 at Nagpur, in which six other officers of the department took part personally and to which several more contributed papers. On the administrative side, the attention of the office as a whole was directed mainly to the consolidation of schemes for giving

meteorological facilities to aviators and making fresh proposals for improving the position of meteorology in general and in creating a new section of agricultural meteorology under the auspices of the Imperial Council of Agricultural Research. The general work of the office is best described by reviewing briefly the activities of the different sections separately.

(*a*) *General Section.*—This section is responsible for the administration of headquarters and sub-offices and deals with budget and accounts, establishments, general registry, all technical questions involving change of policy or fresh expenditure and the co-ordination of the technical work of the department. During the year it had to cope with the administrative work involved in the opening of the new forecasting centre at Rangoon and also in connection with the proposed new branch of agricultural meteorology, sanction for which was obtained during the year. This scheme has already been outlined under the " Chief Features " of the year at the beginning of this report. Government sanctioned two research scholarships to be awarded to suitable candidates; the first awards of scholarships were made during the year and the scholars started work. The section also had to prepare proposals for additional staff at Headquarters necessitated by the increase in normal routine and to deal with the effects of the withdrawal by the Telegraph Department of the long standing concession of sending express weather telegrams at ordinary rates. This has resulted in the department having to provide about Rs. 2 lakhs more for telegrams annually.

(*b*) *Weather Section.*—The functions of this section have been partly outlined in previous pages dealing with storm and heavy rain warnings. The section is responsible for the issue of daily weather telegrams, the daily, weekly and monthly weather reports and for the preparation of portions in the Annual Summary of the India Weather Review relating to weather. It has been the feeling for many years that one chart a day is not really sufficient for a proper study of weather changes. All other countries with meteorological services recognise this and generally make three charts a day. All the interests that make use of our weather reports and warnings including the newspaper reading public would be profited both directly and indirectly on account of the anticipated improvement in forecasts and warnings. A proposal to inaugurate a second afternoon chart was therefore made but had unfortunately to be held up owing to the unfavourable financial situation. The 1929 Weather Message Code was revised and brought into line with the new International Code (Copenhagen Code). This new code is called the Weather Message Code 1931. Karachi Meteorological Office broadcasts observations from a number of stations and the code that it used to employ was replaced from the 1st March 1931 by a new " Indian Broadcast Code " prepared by this section. This new code is almost the same as the second form of the Copenhagen Code. A fresh code was devised to give surface landing conditions to pilots of aeroplanes.

(*c*) *Observatories Section.*—This section administers and arranges for the regular inspection of all the departmental observatories that are not under the charge of sub-offices. During the year, with the opening of the sub-office at Rangoon, the administrative control of the Burma observatories was transferred to that office. The administrative control of a few stations in Sind and west Rajputana was handed over to

the Karachi office. Five second class observatories, seven third class observatories and one first class observatory were started during the year. The new Weather Message Code was introduced at most of the observatories in India, Burma and Ceylon. A new hand-book of Instructions to Observers at second and third class observatories was published and distributed.

(*d*) *Instruments Section.*—As usual, the section remained responsible for the test, standardisation, repair and issue to observatories of special and self-recording meteorological instruments. During the year 51 self-recording and 117 other instruments were issued, 29 self-recording and 45 other instruments tested and 141 instruments repaired. A beginning was made towards equipping all first class observatories with a standard set of up-to-date autographic instruments. The section provided instrumental equipment for an experimental marine expedition in the Bay of Bengal and for a temporary research observatory at Khandala in charge of one of the research scholars. The work of remodelling dial pattern anemometers proceeded apace and it was decided to replace gradually the existing anemometers by the I. M. D. cyclometer type. With a view to standardise instrumental equipment employed in the department, specifications, drawings and instructions for the care of each type of instruments were prepared. An improved pattern of windvane with splayed tail and ball bearings was developed and provisional specification drawn up. A study of the atmospheric potential gradient with special reference to the study of fine weather changes in the electrical field near the ground was undertaken.

(*e*) *Marine Section.*—In addition to carrying out its usual duties of co-ordinating the work of collection, examination and study of ships' weather logs and of maintaining contact with shipping interests, the section organised towards the end of the year a small marine tour in the Bay of Bengal on the routes from Calcutta to Rangoon and Rangoon to Madras in order to find out the best methods of organising marine expeditions in the future. At the instance of the Captain-Superintendent of the I. M. M. T. S. Dufferin, the papers on meteorology written by the cadets during the course of their examinations were judged and a prize from this department given to the best pupil. It is hoped to be able to render similar service in future years. At the instance of the marine departments of the Governments of Bombay and Bengal a brochure on " Winds, Weather and Currents on the Coasts of India and the Laws of Storms " was compiled for the benefit of mariners in Indian waters, and was sent to press.

(*f*) *Upper Air Section.*—Sounding balloon work was carried on at Poona from April to June and from November to March. During the monsoon similar work was done at Hyderabad with the co-operation of the Director of the Nizamiah Observatory. The number of meteorographs let off altogether was 145 out of which 78 were recovered. Observations of upper air temperatures and humidities collected by R. A. F. aeroplanes at Peshawar, Quetta and Karachi were tabulated. The upper air data of 1928 in 14 parts were published. A revised pilot balloon code was prepared in collaboration with the Agra Observatory. Some research investigations were completed and others were in progress.

(*g*) *Library Section.*—In addition to the care of the library, this section, as usual, prepared the various seasonal forecasts and carried

on studies relating to them. The seasonal forecasting formulæ discovered by Sir Gilbert Walker were brought up-to-date. The various formulæ as well as individual correlation co-efficients were examined by Fisher's method for testing their significance. The number of books, pamphlets and periodicals either purchased, received as presentation copies or exchange copies was 466. The number of institutions and individuals on the free distribution list of this department was 343 at the end of the year. The routine and research publications of the department as well as those of individual members of the staff are listed in Appendix B.

(*h*) *Climatology Section.*—The routine activities of this department have been described in the last year's administration report. During the year the section also prepared a number of climatic tables for Indian stations required partly for a new work on the climatology of the world, for which Sir Gilbert Walker and the Director-General of Observatories (Dr. Normand) are the joint editors of the portion relating to India.

16. *Upper Air Observatory, Agra.*—This observatory administers all the pilot balloon stations of the department except those at Karachi, Delhi, Calcutta, Rangoon and Poona, where the staffs are under the charge of the local officers. As mentioned above under Chief Features, the work has grown with the opening of new pilot balloon stations and the extension of others, and the staff had to be increased by one Assistant Meteorologist's post and about a dozen technical subordinate posts. A new pilot balloon station was opened at Sambalpur and the two stations in Bengal which were running on a temporary basis under the Nor'-wester scheme were closed down. Preliminary arrangements involving recruitment and training of staff for four new stations, to be opened under the Calcutta-Rangoon Aviation scheme, were made. With the advent of two flights a day at a number of pilot balloon stations along the air routes the demand for hydrogen rose greatly this year and was the highest yet recorded, the output being approximately ~~one and a half million~~ cubic feet. The construction of additional hydrogen plant, though sanctioned, had unfortunately, but unavoidably, to be postponed to the subsequent year. In all 257 sounding balloons were released, including about two dozen from Allahabad during the monsoon. Out of these 124 were retrieved and it was found that a number of them had penetrated the stratosphere as high as 20 to 25 geodynamic kilometres. Some further improvements were introduced in the Dines' type of meteorograph (see Chief Features) as well as in the Chatterjee Indicator designed for determining different levels of temperature in the free air. Soundings with the latter class of instruments were carried on regularly at Agra, Calcutta and ~~Bombay~~ Dacca

To meet the growing needs of the activities at Agra a new building for supplies and stores, another for a godown for carpenters, an additional building for office accommodation and a new transformer house were constructed.

17. *Colaba and Alibag Observatories.*—A weather summary containing the principal features of weather over western India and the chief rainfall amounts has taken the place of the Bombay Daily Weather Report since the commencement of the issue of the Indian Daily Weather Report from Poona. The material for this is telephoned from Poona

to Colaba. The issue is limited to the period 1st May to 30th November and includes from 1st July onwards a bi-weekly weather and crop report for districts.

The routine meteorological, seismological, magnetic and time work at Colaba and Alibag Observatories was carried on as in previous years. A few special instruments such as a microbarograph and a Milne-Shaw seismograph were installed during the year and the old Omori seismograph was put out of action. Wireless time-signals from Bordeaux and Rugby were received in connection with the time-service of the observatory which is responsible for dropping the time-balls in the port of Bombay and maintaining the tower clocks at Ballard Pier and the Prince's Dock. During the year 72 chronometers and watches were received in custody, 38 were issued to R. I. M. ships, 7 to R. N. ships and 33 returned to England for repairs. The Observatory Volume for 1926 was published during the year, those for 1927 and 1928 were sent to press, and considerable progress was also made with the manuscripts of the volume for 1929.

Four research students from the Royal Institute of Science and the Wilson College were engaged in work on meteorological and physical problems under the direction of the Meteorologist. The Meteorologist himself carried on further investigations on the electrical field of overhead thunder-clouds described in last year's administration report. Another piece of research by him was on the electricity of monsoon rains. A paper on the subject contributed to the Indian Science Congress discusses the drop of the potential gradient produced by monsoon rainfall and its relationship with wind, amount of rainfall and charges of raindrops. The results appear to support the breaking drop theory of the origin of electricity in non-thunderstorm rain. The Meteorologist also undertook the analysis of microseisms associated with storms in the Bay of Bengal as recorded by the Calcutta and Bombay Milne-Shaw seismographs, with the object of studying their relationship with the direction of movement of storms.

18. *Alipore Observatory and Meteorological Office, Calcutta.*—Additional staff including a third Assistant Meteorologist was sanctioned and appointed during the year, and the office began preparing a daily afternoon chart from the 1st October, in addition to the regular morning chart. The immediate cause of these additions was the need to supply improved information to aviators, which formed a new addition to the functions of the Alipore Office, which include storm and heavy rain warnings for the Bay of Bengal and the surrounding areas. A special temporary duty was the issue of weather reports and forecasts to the Kanchenjunga Expedition in the summer of 1930, the members of which expressed appreciation of the forecasts. The Alipore Observatory also remains responsible for the test and standardisation and issue to observatories of ordinary meteorological instruments. Its duties include the determination of time by transit observations of stars and the wireless broadcasting of time signals twice a day and dropping the time-balls in the city of Calcutta. During the year, the Port Commissioners decided to discontinue the time-balls belonging to them, namely that on the Port Commissioners' Office and at the Kidderpore Docks. As a result of the increased responsibilities and the two sets of observations a day it was necessary to give up the previous arrangement

of using some of the members of the staff of the office as signallers, and arrangements were made under which the Telegraph Department opened a telegraph office in the Meteorological Office towards the end of the year. Submissions of proposals for a third nor'-wester season of intensive study of weather were postponed mainly on account of the impossibility of Agra observatory being able to make the necessary arrangements for upper work during the nor'-wester season in 1931. A new Milne-Shaw seismograph was installed. The Meteorologist carried on a detailed investigation of nor'-westers in Bengal.

19. *Madras Observatory.*—The Madras Daily Weather Report was published throughout the year. In addition to the usual tables and a summary of the weather situation in the Madras Presidency, a 24 hours' forecast was given during the year as a new feature. The supply of correct time to local shipping and through the inland telegraph system to the whole country continued to be one of the important items of work. With the accurate reception of wireless rhythmic time signals from Bordeaux and Rugby, time determination by transit observations was considered superfluous and with effect from December 1930 the clock correction was deduced from the wireless time signals.

20. *Meteorological Office, Karachi.*—The most important event that affected this office was the projected flight to India of the ill-fated airship R-101, which has already been referred to at some length in the "Chief Features". The Karachi Office had undertaken full responsibility for the supply of weather reports, forecasts and warnings to the Airship on her incoming and return flights over the section east of longitude 48° E. A detailed programme for the supply of weather reports and forecasts, based upon the division of the period of the airship's stay in the region into different epochs, was worked out and exchanged with the programmes of the London and Ismailia services. A temporary telegraph office was opened at the Airship Base Observatory at Drigh Road and the forecasting section at Karachi, temporarily increased by the addition of a forecasting officer from Poona, was shifted there and housed temporarily in hired tents. When all was ready came the news of the tragedy and all the special arrangements were immediately cancelled.

The supply of aviation forecasts to the Imperial Airways mails, the Indian State Air Mail Service, the Dutch and French Air Mail Services which started regular operation in September 1930 and January 1931 respectively, the Royal Air Force, the Flying Boat Squadron of Basra and other fliers, trans-continental as well as local, constitutes the principal work of the Karachi Meteorological Office. For its daily charts the office receives synoptic broadcasts containing 0200, 0600 and 1200 G. M. T. observations from Iraq stations. The reception of Abu Zabal synoptics was temporarily stopped in May but was restarted in September. The synoptic broadcasts from the Air Ministry station at Ismailia were also received and proved useful.

To meet the needs of aviation services a few more stations were added to the list of reporting observatories. Late in November 1930 it was learnt that the Indo-European Telegraph Department would close down in the interior of Persia from the 1st March 1931 and that their Persian Gulf Section would be taken over by the Imperial and International

Communication Company. The question of the continuance of such observatories in the Persian Gulf and in Persia as are being worked by the telegraph personnel came up for serious consideration. The co-operation of the Consulate authorities in the interior of Persian stations was enlisted and with the help of the Director of the Indo-European Telegraph Department, Karachi, it has been arranged that the Imperial and International Communication Company will take over the observational work at the observatories in the Persian Gulf on the existing conditions. Wing Commander Howe of the Flying Boat Squadron of the Persian Gulf came from Basra to discuss with the Meteorologist the possibility of the supply of regular meteorological information for the Basra-Bahrein-Muscat-Gwadar-Karachi route.

The Meteorologist prepared a brochure on " The Meteorology of the Persian Gulf and Mekran " giving an account of the present state of knowledge regarding weather over the region in question. As mentioned above under Chief Features, some work was also done in connection with the observations and analysis of temperatures at four different heights on the 264 ft. mast at the Airship Base Observatory. The electrical resistance thermometers were functioning at the four heights for a few months but were put out of use because of contact trouble in the Thread Recorder; and the bulk of the observational material therefore consists of the records of four ordinary thermographs.

21. *Kodaikanal Observatory.*—The solar and astronomical researches during the calendar year 1930 have been summarised in the Annual Report of the Kodaikanal Observatory. An addition to the routine work has been made by the inclusion of the measurement and tabulation of prominences photographed in hydrogen light from January 1st, 1929. Another addition to the routine was a tabulation of areas of $H\alpha$ absorption markings uncorrected for the curvature of the Sun's surface. The daily character figures for solar activity according to $H\alpha$ disc spectroheliograms were communicated quarterly to the Observatoire Fedéral, Zurich, for publication. Occasional staff meetings were held for the discussion of different scientific topics or papers.

One or two schemes regarding the amenities necessary for Kodaikanal Observatory were under consideration. The first is the scheme for municipal water supply. This was during the year in its rudimentary stage and included direct pumping of water into the reservoir near the observatory which will also supply other tax-payers in the vicinity. The Sanitary Engineer suggested that the Government of India should be asked to contribute to the capital cost. Another necessity for the Kodaikanal Observatory is a building to accommodate library, photographic records and office rooms. The existing accommodation is being found insufficient, because the library has been growing and the stock of photographic records has been accumulating at a rapid rate. Plans were prepared for the new building, but nothing further could be done on account of the adverse financial position.

22. *Meteorological Office, New Delhi.*—This forecasting centre continued its work in the hired building at 19, Prithviraj Road. Two weather charts, (8 hrs. and 17 hrs.), were prepared daily. Issuing weather reports and forecasts to aviators for the region between Jodhpur and Gaya remained the chief function of this office.

23. *Meteorological Office, Rangoon.*—As a part of the extension of the provision of meteorological facilities for aviation on the air-route from Calcutta to Rangoon and Victoria Point, this office was opened in September 1930. The office commenced functioning as a forecasting centre by the middle of December, its responsibility being limited on one side by Akyab and on the other by Victoria Point. It prepares two sets of weather charts daily and has the administrative control of some 20 observatories in Burma, of which it also will prepare the climatological data.

24. *Meteorological Offices at Quetta and Peshawar.*—As mentioned in the previous year's Administration Report, a Meteorologist from the India Meteorological Department held charge of the centre at Peshawar until the return of the R. A. F. Officer. Immediately after this, the R. A. F. Meteorological Officer at Quetta left and the officer of the Indian Meteorological Service was posted to Quetta. These officers issued detailed local forecasts and warnings each for his neighbourhood, as well as general forecasts for the Delhi-Peshawar and Quetta-Karachi air-routes. The work of the first class observatories at Quetta and Peshawar was carried out as usual.

25. *Other Observatories.*—The position as regards number of observatories of various classes is shown in the table below, which also gives the corresponding figures at the end of the year 1929-30. For a classification of these observatories, the reader is referred to Appendix C:—

	on 31st March 1931.	on 31st March 1930.
I Class . . .	14	13
II Class . . .	153	148
III Class . . .	85	78
IV Class . . .	23	23
V Class . .	19	19
Non-departmental .	54	52

The records of the non-departmental observatories were scrutinised by this department and in most cases utilised in the daily weather reports and other departmental publications. The importance of these observatories need hardly be emphasised and the co-operation of the Indian States and other public bodies who maintained such observatories for the furtherance of the study of Indian meteorology is much appreciated.

Rainfall Registration.

26. The system of provincial rainfall registration, for which the Director-General of Observatories is the consulting authority, continued its usual widespread work satisfactorily. The following table based

on reports for 1930-31 shows the number of raingauges in each province and in the Indian States at the end of the year and the number of inspections of these during the year with corresponding figures for the preceding year for comparison :—

No.	Province,	Number of Raingauges at the end of			Number of Inspections.			Remarks.
		1930-31	1929-30	Change	1930-31	1929-30	Change	
1	Burma . .	214	214	0	216	211	+5	Satisfactory.
2	Assam . .	129	129	0	113	118	—5	Do.
3	Bengal . .	236	234	+2	206	210	—4	Generally good.
4	Bihar and Orissa	298	297	+1	260	275	—15	Generally satisfactory.
5	United Provinces	269	269	0	228	239	—11	Satisfactory.
6	Punjab . .	154	154	0	120	121	—1	Generally good.
7	North-West Frontier Province.	33	33	0	26	28	—2	Do.
8	Baluchistan .	76	77	—1	53	64	—11	Good
9	Bombay . .	303	304	—1	262	266	—4	Satisfactory.
9(a)	Western India States.	27	27	0	27	27	0	Do
9(b)	Baroda . .	13	13	0	10	7	+3	Do.
10	Rajputana .	332	342	—10	305	322	—17	Generally good
11	Central India .	197	197	0	142	158	—16	Satisfactory.
12	Jammu and Kashmir	34	34	0	28	16	+12	Generally good.
13	Central Provinces	115	115	0	96	96	0	Generally good (excluding 76 raingauges under Irrigation Department.)
13(a)	Berar .	42	42	0	42	39	+3	
14	Hyderabad .	54	19	+35	2	19	—17	Steps being taken to improve the conditions of all the new raingauges.
15	Mysore . .	239	239	0	225	205	+20	Generally good.
16	Coorg . .	9	9	0	6	5	+1	Good.
17	Madras . .	510	510	0	488	486	+2	Do.
		Net change +26			Net change —57			

Heavy Rainfall Reports.—Heavy rainfall is often so very local that small unrepresented areas can have as much as 10 inches without the weather chart with the present net-work of daily reporting stations conveying the least suggestion of the local deluge. To obtain reports of

such local heavy rain promptly for the Daily Weather Report, it was arranged 10 years ago that observers at the provincial raingauge stations should telegraph to forecasting centres falls of 5 inches or more. The number of such telegrams received during 1929-30 was 233 as compared with 248 in the previous year.

Snowfall Registration.—Information about the distribution and the time of occurrence of snowfall in the Himalayas and the Afghan mountain areas was on the whole tolerably complete and the thanks of the department are due to the various officers who collected and forwarded the reports.

Concluding Remarks.

27. The Meteorological Department owes a large part of its usefulness to the sympathetic assistance it receives from other departments. Officers of various Government departments help the meteorological work as Honorary Superintendents of Observatories or in other capacities. The Posts and Telegraphs Departments assist this department in the rapid transmission of meteorological information particularly in connection with the warning services.

Weekly telegrams are received from April to October from the Director, Royal Alfred Observatory, Mauritius. These telegrams give valuable information of the weather conditions in the Indian Ocean, and the department is indebted to these observatories for the punctual transmission of the information.

The department is greatly indebted for important information on meteorological conditions prevailing before and during the south-west monsoon to the Controller, Physical Department, Cairo; the Directors of the Observatories at Buenos Ayres, Santiago, the Astronomer Royal, Cape Town; Director L'Observatoire Physique Central, Leningrad; the Secretary, Friends' Industrial Mission, Banani Pemba, Zanzibar; the Principal Medical Officer, Tanganyika Territory, Dar-es-Salam; the Commonwealth Meteorologist, Melbourne; Director of Agriculture, Salisbury, Rhodesia; Chief of the Weather Bureau, Washington. Thanks are due to the Director, Koninklijk Magnetisch und Meteorologisch Observatorium, Batavia, for similar information and also for the daily weather telegrams from Sabang in Sumatra during the cyclone months April, May and October to December.

Thanks are due to the Marine Superintendents of the British India Steam Navigation Company, the Scindia Steam Navigation Company and the Asiatic Steam Navigation Company, for continuing the arrangement under which many captains of their fleets send weather logs to this department; and to Mackinnon Mackenzie and Company for affording facilities for the experimental tour on their mail steamer in the Bay of Bengal, to study possibilities of marine meteorological expeditions. Captain Whish, Principal Officer, Mercantile Marine Department, Bombay, Commander A. G. Kinch, Deputy Conservator of Port, Bombay, and Commander Norcock, Deputy Conservator of the Port of Calcutta, have been willing helpers of this department, for which it is grateful to them.

The department is indebted to the Government of His Exalted Highness the Nizam of Hyderabad for the help rendered in carrying on

sounding and pilot balloon work at the Nizamiah Observatory, and to the Governments of Mysore and Travancore for their co-operation by regular collection of pilot balloon data at Bangalore and Trivandrum respectively.

Thanks are due to the Eastern Telegraph Company for charging this Department half the usual rates for the transmission of South American weather telegrams. Thanks are also due to the various pilots of the Imperial Airways Limited for the supply of weather logs to this Department; to the various ships' officers, who send their marine weather logs direct to this Department; to the Superintendent of the Colombo Observatory for the useful help he has rendered from time to time in connection with storm warning work.

C. W. B. NORMAND,

Director-General of Observatories.

POONA;

The 11th September 1931.

APPENDIX A.

THE STAFF OF THE INDIA METEOROLOGICAL DEPARTMENT AS IT STOOD ON 31ST MARCH 1931.

METEOROLOGICAL OFFICE, POONA.

Director-General of Observatories:
C. W. B. Normand, M.A., D.Sc. (Edin.).

General Section.

Meteorologist	V. V. Sohoni, B.A. (Hons.), B.Sc. Bombay.
Assistant Meteorologist	C. P. Venkataramier, M.A. (Madras) (Temporary).
Superintendent	Shamsul Haq, Khan Saheb.
Assistants	6.
Stenographers	2.
Cashier	1.
Clerks and typists	13.

Weather Section.

Meteorologist	S. Basu, M.Sc. (Allahabad).
Assistant Meteorologist	B. N. Desai, M.Sc. (Bombay), Ph.D. (Edin.), B.A., LL.B. (Bombay).
Assistants	2.
Clerks and tabulators	12.
Draftsmen	5.

Observatories Section.

Meteorologist	K. J. Kabraji, B.A. (Hons.), B.Sc. (Bombay), M.Sc., Ph.D. (London).
Assistant	1.
Inspector of Observatories	1.
Clerks	3.

Marine Section.

Meteorologist	S. Mal, M.Sc., Ph.D., D.I.C. (London) (on probation).
Assistant	1.
Clerk	1.
Draftsman	1.

Instruments Section.

Meteorologist	J. M. Sil, B.A. (Calcutta), B.Sc. (Engg.) (Boston Tech.).
Assistants	2.
Clerks	2
Draftsman	1.
Senior and Junior Observers (temporary)	2.
Store-keeper (temporary)	1.
Mechanics (temporary)	2.
Skilled Mistri (temporary)	1.
Overseer (clerk of works, temporary) (abolished from 1st April 1931)	1.

Upper Air Section.

Meteorologist	K. R. Ramanathan, M.A., D.Sc. (Madras) (on leave).
	L. A. Ramdas, M.A., Ph.D. (Calcutta), Meteorologist (officiating).
Assistant Meteorologist	Barkat Ali, B.A., M.Sc. (Punjab).
	S. P. Venkateshwaran, B.A. (Hons.) (Madras) (temporary).
Assistant	1.
Clerks	2.
Senior and Junior Observers	5 (including 3 Senior Observers of the establishment of Agra, temporarily transferred).
Draftsman	1.
Clerk (temporary)	1.
Observer (temporary)	1.

Library Section.

Meteorologist	S. R. Savur, M.A. (Madras), Ph.D. (London).
Assistant Meteorologist	M. V. Unakar, Rao Saheb, B.A. (Bombay).
	S. L. Malurkar, B.Sc. (Mysore), M.Sc. (Cantab.) (temporary).
Assistants	2.
Librarian	1.
Clerks	5.
Draftsman	1.

Climatology Section.

Meteorologist	S. R. Savur, M.A. (Madras), Ph.D. (London).
Assistant Meteorologist	V. Doraiswamy Iyer, B.A. (Madras).
Assistant	1.
Clerks	10.

UPPER AIR OBSERVATORY, AGRA.

Meteorologist-in-Charge	G. Chatterjee, M.Sc. (Calcutta).
Meteorologist	N. K. Sur, D.Sc. (Allahabad).
Assistant Meteorologists	B. N. Sreenivasiah, M.Sc. (Calcutta).
	D. M. Patel, B.Sc. (London), A.R.C.S. (on probation).
	S. K. Das, M.Sc. (London), D.I.C. (offg.).
Superintendent	Babu Ram Samnol (on probation).
Mechanical Assistant	Chainsukh.
Chief Observer	1.
Chief Computer	1.
Foreman	1.
Clerks or Observers	42 (at Agra).
Clerks or Observers	71 (out-station staff).
Mechanics (temporary)	10.
Clerks and Observers (temporary without time limit sanctioned by Government)	9.
Clerks and Observers (temporary with time limit sanctioned by D. G. O. and Government)	5.
Enginemen (permanent)	2.

COLABA AND ALIBAG OBSERVATORIES, BOMBAY.

Meteorologist	S. K. Banerji, M.Sc., D.Sc. (Calcutta).

At Colaba.

Head Clerk	P. A. Salvi, B.A., LL.B. (Bombay) (on probation).
First Assistant	1.
Observers	6.
Cashier	1.
Marine Clerk	1.
Typist and Stenographer	1.

At Alibag.

Observers	2.

ALIPORE OBSERVATORY AND METEOROLOGICAL OFFICE, CALCUTTA.

Meteorologist	S. N. Sen, M.Sc. (Calcutta and London), Ph.D. (London).
Assistant Meteorologists	M. G. Subrahmanyam, Rao Bahadur, B.A. (Madras), LL.B. (Bombay).
	A. K. Das, M.Sc. (Calcutta), D.Sc. (Paris) (on probation).
	C. Ramaswamy, M.A. (Hons.) (Madras) (offg.).
Superintendent	K. P. Banerji, M.A.
Professional Assistant	N. P. Chatterji, M.Sc. (Calcutta) (on probation).
Chief Observer	G. N. Mukherji.
Clerks (upper division)	5.
Clerks (lower division)	25.
Stenographer	1.
Draftsmen	3.
Observers	4.
Inspector of Observatories	1.

METEOROLOGICAL OFFICE, NEW DELHI.

Meteorologist	S. C. Roy, M.Sc. (Calcutta), D.Sc. (London).
Assistant Meteorologist	B. K. Roy, M.Sc. (Calcutta) (on probation).
Professional Assistant	V. V. Subbu, M.A., B.L. (Madras) (on probation).
Inspector of Observatories	1.
Head Clerk	1.
Cashier and Typist	1.
Clerks	6.
Observers (upper air)	3.
Observers (surface) (under training)	2.

METEOROLOGICAL OFFICE, KARACHI.

Meteorologist	B. N. Banerji, M.Sc. (Allahabad), Ph.D. (Cantab).
Assistant Meteorologists	P. R. Krishna Rao, B.Sc. (Mysore).
	K. Das, M.Sc. (Punjab), Ph.D. (London) (on probation).
Chief Observer	1.
Head Clerk	1.
Inspector of Observatories	1.
Steno-typist	1.
Clerks or Observers	11.
Clerks or Observers (temporary)	5.

SOLAR PHYSICS OBSERVATORY, KODAIKANAL.

Director	T. Royds, D.Sc. (London).
Assistant Director	A. L. Narayan, M.A., D.Sc. (Madras), F.I.P.
Assistants	3.
Recorders	4.
Mechanic	1.
Book-binders	2.

METEOROLOGICAL OFFICE AND OBSERVATORY, MADRAS.

Assistant Meteorologist	A. A. Narayana Aiyar, B.A. (Madras).
Time Assistant	1.
Weather Assistant	1.
Clerks	4.
Observers	3.
Printer	1.

METEOROLOGICAL OFFICE, RANGOON.

Meteorologist	S. K. Pramanik, M.Sc. (Lucknow), Ph.D. (London), D.I.C. (London).
Assistant Meteorologist	S. S. Lal, M.Sc. (Lucknow), D.I.C. (London), M.Sc. (London) (temporary).
Professional Assistants	H. R. Puri, M.Sc. (Punjab). U. N. Ghosh, M.Sc. (Calcutta) (on probation).
Inspector of Observatories	1.
Clerks	10.
Observers	4.

METEOROLOGICAL OFFICE, No. 3 (INDIAN) WING, R. A. F., QUETTA.

Meteorologist	A. K. Roy, B.Sc. (Calcutta), B.A. (Oxon.) (on probation).
Senior Clerk	1.
Junior Clerks	3.

METEOROLOGICAL OFFICE, No. 1 (INDIAN) GROUP HEADQUARTERS, R. A. F., PESHAWAR.

Meteorological Officer (R. A. F.)	R. G. Veryard, Ft./Lt.
Senior Clerk	1.
Junior Clerks and Observers	3.

APPENDIX B.

PUBLICATIONS.

The following departmental publications were issued or sent to press during the year:—

I.—*Periodical.*

1. Daily Weather Reports:
   - i. Indian Daily Weather Report (to date).
   - ii. Calcutta Daily Weather Report (to date).
   - iii. Delhi Daily Weather Report (to date).
   - iv. Karachi Daily Weather Report (to date).
   - v. Madras Daily Weather Report (to date).
2. Weekly Weather Report (to date).
3. Monthly Weather Report (to date).
4. India Weather Review, Annual Summary for 1929, in seven parts:
   - i. Introduction.
   - ii. Part A.—Summary of Weather and Rainfall.
   - iii. Part B.— Snowfall.
   - iv. Part C.—Storms and Depressions.
   - v. Part D.—Annual Tables.
   - vi. Part E.—Seismic Records.
   - vii. Part F.—Errata to Monthly Weather Reports.
5. Daily Rainfall of India for 1927.
6. Monthly Rainfall of India for 1927.
7. Upper Air Data, 1929, in 14 parts:
   - i. Parts 1—12.—Winds in January to December.
   - ii. Part 13.—Monthly Means of Pilot Balloon Data and Monthly Frequencies of Clouds.
   - iii. Part 14.—Sounding Balloon Data.
8. Seasonal Memoranda:
   - i. Memorandum on the Probable character of the weather in North-West India in January, February and March 1931.
   - ii. Statement of the Rainfall and Snowfall of North-West India in January, February and March 1930 and a comparison of the Seasonal Forecast with the actual Precipitation.
   - iii. Memorandum regarding the probable amount of Monsoon Rainfall in 1930.
   - iv. Memorandum on the Rainfall of June and July and the probable amount during August and September 1930.
   - v. Statement of actual Rainfall in the monsoon season, June to September 1930, and a comparison of the Forecasts with the actual Rainfall.
9. Magnetic, Meteorological and Seismographic Observations made at the Government Observatories, Bombay and Alibag, in the year 1926.
10. Report on the Administration of the Meteorological Department of the Government of India in 1929-30.
11. Annual Report of the Kodaikanal Observatory.

II.—*Occasional.*

1. Memoirs of the India Meteorological Department:
   Vol. XXV, Part VII.—An Analysis of the Base Line values of Autographic Instruments, by Sudhansu Kumar Banerji, D.Sc.

2. Scientific Notes:

Vol. II—

No. 16.—Winds in the first 3 Km. over Port Blair, by K. P. Ramakrishnan, B.A.

No. 17.—Parts A—D.—Tables of Monthly Average Frequencies of Surface and Upper Winds up to 3 Km. in India.

Vol. III—

No. 18.—The Structure of the Madras Storm of January 1929, by K. R. Ramanathan, M.A., D.Sc., and A. A. Narayana Iyer, B.A.

No. 19.—Distribution of Air Density at M. S. L. over India, by U. N. Ghosh, M.Sc.

No. 20.—Correlation between Rainfall in North-West India and Height of Indus River at Bukkur, by Rao Saheb Mukand V. Unakar, B.A.

No. 21.—Upper Air Circulation over India and its neighbourhood up to the Cirrus Level during the Winter and the Monsoon, by H. C. Banerji, M.Sc., and K. R. Ramanathan, M.A., D.Sc.

No. 22.—The Structure and Movement of a storm in the Bay of Bengal during the period 13th—19th November 1928, by K. R. Ramanathan, M.A., D.Sc.

No. 23.—Historical Note on the Catch of Rainganges, by H. R. Puri, M.Sc.

No. 24.—On the utility of the observations of Barometric characteristics and tendencies for forecasting Weather in North-West India, by Ft.-Lieut. R. P. Batty, B.A.

No. 25.—Heights of clouds in India as determined from Pilot Balloon Ascents, by the late M. V. Narayanan, B.A., and M. P. Manna.

No. 26.—Some statistical Relations between Temperature and Pressure in the upper atmosphere over Agra and Batavia, by S. Gopal Rao, B.A.

3. Kodaikanal Observatory Bulletins:

No. LXXXVII.—Summary of Prominence Observations for the first half of the year 1929.

No. LXXXVIII.—Summary of Prominence Observations for the second half of the year 1929.

No. LXXXIX.—The Rotation of Hydrogen Absorption Markings and their Height above the Surface of the Sun.

4. Meteorology of the Persian Gulf and Mekran, by B. N. Banerji, M.Sc., Ph.D., F. R. Met. Soc.

5. Five-Day Normals of Maximum and Minimum Temperature and Accumulated Rainfall.

6. Winds, Weather and Currents on the Coasts of India and the Laws of Storms.

7. Instructions to Observers at the Second and Third Class Observatories, 1930.

8. Weather Code, 1931.

9. Pilot Balloon Code, 1931.

10. Handbook of Codes, 1931.

The following meteorological and other papers or notes were contributed by members of the staff to extra-departmental journals:—

Normand, C. W. B.—

"The Upper Atmosphere."—Presidential address at the Section of Mathematics and Physics of the Indian Science Congress, January 1931—Proceedings, Asiatic Society of Bengal.

Banerji, S. K.—

Microseisms associated with disturbed weather in the Indian seas—Philosophical Transactions of the Royal Society, Series A, Vol. 229, pp. 287—328.

The Electric Field of Overhead Thunder-clouds—Quarterly Journal of the Royal Meteorological Society, Vol. 56, No. 236, July 1930, pp. 305—334.

Effect of Indian Mountain Ranges on Air Motion—Indian Journal of Physics, Vol. V, Part 7, February 1931, pp. 699—745.

Chatterjee, G.—

A recording plate for use with Meteographs of Dines Type—Journal of Scientific Instruments, Vol. 7, No. 4, 1930, p. 130.

Chatterjee, G., and Sur, N. K.—

The Thermal Structure of the Free Atmosphere over Agra—Gerlands Beiträge zur Geophysik, Vol. 25, 1930, pp. 266—278.

Sohoni, V. V.—

Weather Types associated with Nor'-westers in Bengal—Journal and Proceedings of the Asiatic Society of Bengal, Vol. for 1930.

Sen, S. N.—

Note on the Mechanism of Tornadoes in Bengal—Nature, Vol. 127, January 24, 1931, pp. 128—129.

Sen, S. N., and Unakar, M. V.—

Ancient Hindu Meteorology—Meteorological Magazine, Vol. 65, No. 779, December 1930, pp. 263—264.

Ramanathan, K. R., and Mal, S.—

A Laboratory Method of Demonstrating the Formation of Fronts and Vortices when there is a discontinuous movement in a fluid—Nature, Vol. 127, 1931, p. 272.

Mal, S.—

Forms of Stratified Clouds—Beit. zur Physik der Fr. atmosphare, Bd. XVII, Hft. 1, 1930, pp. 40—68.

Narayan, A. L., and Rao, A. S.—

Notiz über den Bau des Pb. IV spektrums—Zts. fur Physik, Bd. 61, 1 & 2 Hft, pp. 149—150.

Desai, B. N., and Patel, A. M.—

The Kinetics of Coagulation—Transactions of the Faraday Society, Vol. XXVI, Part 3, 1930.

Effect of non-electrolytes on the precipitation of Thorium Hydroxide from its salt solution in presence of Alkali—Journal of Indian Chemical Society, Vol. VII, No. 2, 1930.

Influence of Non-Electrolytes on the coagulation of colloidal Thorium Hydroxide with the progress of Dialysis of the latter in the presence and absence of electrolytes—Kolloid. Zts., Vol. 51, Part 3, 1930.

Das, A. K.—

On collisions of Photons—Physical Review, January 1931.

Origin of Cosmic Penetrating Radiation—Naturwissenschaften, 1931.

Bakshi, R.—

On raingauges in frosty weather—Meteorological Magazine, Vol. 65, 1930.

APPENDIX C.

Classification of Observatories, etc.

Weather observatories.—The functions of a weather observatory are the recording of weather elements through the agency of an observer with the help of instruments near the ground (as distinct from upper air observations obtained by means of balloons, etc.). Observatories where the staff is provided and paid for by other agencies, for instance Indian States, are called non-departmental, although instruments are supplied by the Meteorological Department. These surface observatories are classified thus:—

First Class.—Such observatories are furnished with autographic instruments for continuously recording pressure, temperature, humidity, wind direction and velocity and rainfall, in addition to instruments read by eye. They can undertake special observations (*e.g.*, on atmospheric electricity, terrestrial magnetism, seismology), some of the first-class observatories also determine time. The staff required varies from two part-time observers to about four full-time observers according to the amount of special work and of computation and tabulation of data.

Second Class.—At second class observatories observations are taken two or three times daily and telegraphed to one or more forecast centres. The existing standard times of observation in India are 8 hrs. (local time) and 17 hrs. I. S. T., the observations being made by a part-time observer on Rs. 25 per mensem generally.

Third Class.—The observatories belonging to this class are those where (*a*) readings are taken daily at 8 hrs. (local time) and sent by telegram to one or more forecast centres or (*b*) readings are recorded twice daily at 10 hrs. and 16 hrs. (local time) but not telegraphed. At each (*a*) type observatory there is one part-time observer on Rs. 15 a month. Practically all (*b*) type observatories are non-departmental.

Fourth Class.—At such observatories either observations of temperaure, wind and rainfall only or of temperature and rainfall only are recorded. The staff at a fourth class observatory consists of a part-time observer on an allowance not exceeding Rs. 12 a month.

Fifth Class.—At these observatories part-time observers on an allowance of Rs. 5 a month record and telegraph rainfall only.

Pilot Balloon Observatories.—At these observatories pilot balloons (*i.e.*, balloons without attached instruments) are released and observed through special theodolites for the determination of wind directions and velocities at various heights in the free atmosphere. The minimum staff is two full-time observers for one balloon flight per day and three full-time observers and a balloon maker for two balloon flights per day.

Upper Air Observatory.—At such an observatory in addition to the pilot balloon work observations of upper air temperatures, humidities and pressures up to heights of about 15 miles by means of sounding balloons (*i.e.*, with instruments attached), are undertaken.

Solar Physics Observatory.—The department has such an observatory at Kodaikanal equipped with photoheliograph, spectroheliograph, etc., where special work on solar physics is done.

Forecast Centres.—These centres are located at different meteorological offices such as Calcutta, Karachi, Delhi, etc., where weather observations are collected by telegram from a number of observatories and plotted on weather charts, which form the basis of weather reports and forecasts. Of these centres there are two types, the first being the main centres serving a large area for general purposes such as the headquarters office at Poona and the second the regional centres serving more limited areas for special purposes, for instance air routes.

MGIPC—L—VIII-3-29—7-11-31—450.

Report on the Administration of the Meteorological Department of the Government of India in 1931-32.

CALCUTTA: GOVERNMENT OF INDIA
CENTRAL PUBLICATION BRANCH
1932

Price As. 8 or 10d.

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1934

Report on the Administration of the Meteorological Department of the Government of India in 1931-32.

CALCUTTA: GOVERNMENT OF INDIA
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Association Press, Calcutta.
Chukervertty, Chatterjee & Co., Ltd., 13, College Square, Calcutta.
The Book Company, Calcutta.
James Murray & Co., 12, Government Place, Calcutta. (For Meteorological Publications only).
Ray Chaudhury & Co., 68-5, Ashutosh Mukherji Road, Calcutta.
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* Bengal Flying Club, Dum Dum Cantt.
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N. M. Roy Chowdhury & Co., 11, College Sqr., Calcutta.
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City Book Co., Madras.
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The Popular Book Depôt, Bombay.
Lawrence & Mayo, Ltd., Bombay.
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The International Book Service, Poona 4.
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*Hossenbhoy Karimji & Sons, Karachi.
The English Bookstall, Karachi.
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Keale & Co., Karachi.
Ram Chandra & Sons, Ambala, Kasauli.
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The North India Christian Tract and Book Society, 18, Clive Road, Allahabad.
Ram Narain Lal, Katra, Allahabad.
"The Leader," Allahabad.
The Indian Army Book Depôt, Dayalbagh, Agra.
The English Book Depôt, Taj Road, Agra.
Gaya Prasad & Sons, Agra.
Narain & Co., Meston Road, Cawnpore.
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The Upper India Publishing House, Ltd., Literature Palace, Ammuddaula Park, Lucknow.
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Bheema Sons, Fort, Bangalore City.
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Report on the Administration of the Meteorological Department of the Government of India in 1931-32.

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CHIEF FEATURES OF THE YEAR.

Retrenchment overshadowed all the departmental activities. Early in the year orders were received to cut down current expenditure by 10 per cent. Every effort was made to meet this demand by curtailing expenditure under weather telegrams, contingencies and allowances, by reducing the number of inspections, cutting out the annual officers' conference and postponing

the opening of a number of pilot balloon stations. By the end of the year, the considerable saving of 17 per cent. had been achieved, but unfortunately not all of this is a real saving, because certain telegraphic charges are not due for payment until the following year.

The original demand for a temporary 10 per cent. cut proved to be merely a mild fore-runner of worse to come. When the financial stringency grew more acute, it was made clear that some permanent retrenchment steps would be imposed and the department had to estimate the relative effects of permanent 10 per cent., 25 per cent. and 50 per cent. cuts in its expenditure. The consideration of permanent retrenchment measures made it necessary to review the reasons for the recent growth and existing organisation of the department. Thoughts were driven back to the retrenchment campaign of 1922-23, when

"despite the already restricted activities of the meteorological department and without regard to the fact that for several years complete collapse had barely been escaped, the department also was instructed to fall into line." (*Administration Report for 1924-25, page 14.*)

Against the drastic steps that had then to be taken, vigorous protests were soon.

"made by the Press and by various associations such as the Chambers of Commerce of Bengal, Bombay, Madras and Narayanganj, the Associated Chambers of Commerce for India and the Association of Marine Insurance Agents. The Committee of Inquiry on the loss of the S.S. "Okara" also criticised the new retrenchment arrangements in so far as they involved the issue of storm warnings for the Bay from Simla instead of from Calcutta. One by one, most of these retrenchments have been found to have been mistakes, and there is now no question that the blind application of general instructions to reduce expenditure, to a department which has always lived at the lower limit of outlay, was a very ill-advised step." (*Administration Report for 1924-25, page 14.*)

There is no doubt about the fact that by 1924, as a result of war-time restrictions and post-war retrenchment, the department had become under-staffed, ill-equipped and insufficiently provided with funds. Government recognised this and began to take action to remedy the defects. Later, the demand for the opening of international air-routes across India gave rise to an expansion of the weather organisation for aviation. Thus, such growth of the department and its budget as took place between 1925 and 1931 was the direct result of public demands by the commercial, maritime and flying communities.

Shortly before the year under review began, the department had pointed out, and Government had sympathised with, lines of further useful extension of its work. But all such ideas had to be given up, because it was made clear that the need for retrenchment must be made to prevail over every other consideration. Eventually Government decided to impose a permanent saving of over 25 per cent. in the departmental budget, *i.e.*, a cut of over Rs. 6,00,000. This presented a problem of considerable magnitude. The general principles, that were kept in view were, first, to give up those items of expenditure which could be dispensed with with least dislocation of work and loss of efficiency ; secondly, to leave the basic structure intact and to give up activities which, later on, with more propitious financial conditions, could be comparatively easily resumed ; and lastly to create the minimum umployment or hardship to personnel consonant with the need to yield the

department's quota of savings. After mature consideration Government ultimately decided upon the following principal steps :—

(*a*) the reduction of the 140-year old observatory at Madras to the status of a pilot balloon station,

(*b*) the abolition of the Delhi Meteorological Office, including the pilot balloon station,

(*c*) the reduction of the Rangoon Meteorological Office to the status of a pilot balloon station, and

(*d*) various lesser items of retrenchment, including the abolition of 4 pilot balloon stations sanctioned in connection with the civil and military aviation schemes, the discontinuance of the grant of two Research Scholarships sanctioned a year ago as an experimental measure, and a general reduction in contingent expenditure, in the expenditure on imported foreign stores and in weather telegrams.

The retrenchment steps in the Rangoon and Madras offices typify two extremes, the one closed almost as soon as it was opened, the other having lasted as an astronomical or meteorological centre for the long span of 140 years and now reduced to the status of a pilot balloon station. Established as an astronomical observatory by the East India Company as far back as 1792, the Madras Observatory is the oldest institution in the department. A succession of well-known astronomers including J. Goldingham, T. G. Taylor, N. R. Pogson, Michie Smith carried on the work of the observatory for over 100 years until 1899,* when astronomical research was transferred to Kodaikanal, and the astronomical duties at Madras became the supply of time to the Indian Telegraph system and to Madras City and Port, while its meteorological duties remained those of a first-class weather observatory and the publication of a daily weather report for South India. From the 1st March 1932, the building in which astronomical work had been continued uninterruptedly for 140 years under the charge of a gazetted officer witnessed the end of all astronomical work there, the abolition of the daily weather report and of the gazetted officer's post.

It is sometimes said, and with much truth, that India is an ideal country for aviation, because, in certain seasons of the year the weather offers few dangers to aviators. On the other hand, it can be said with equal truth that portions of the routes in other seasons of the year are amongst the most hazardous of the main air routes of the world. The worst portion is perhaps the Calcutta—Rangoon route in the height of the monsoon. There are many other dangers such as duststorms and the Bengal nor'westers, for the forecasting of all of which the departmental efficiency (and therefore the safety to aviation) diminishes as a result of the closure of the forecasting centres at Rangoon and Delhi. The 4,000 miles of the international air-route between the Persian Gulf and south Burma, a distance greater than that between London and Bushire, are now served by two forecasting centres only, at Calcutta and Karachi respectively, both of which are limited in staff and in the number of weather reports received daily. The result is that the meteo-

* For fuller account of Madras Observatory's history, *see* Administration Report for 1925-26.

rological service is not able to attain the standard recommended in Annexe G of the International Air Convention which is given as Appendix " C " at the end of this report. It is to be hoped that, when financial conditions sufficiently improve the skeleton weather service now being maintained will receive early consideration to increase the safety of regular flying.

It is also to be noted that if the Rangoon Office had been continued or if it were resumed, its value would be great in the event of the separation of Burma from India, because it would then be possible to hand over to Burma a working meteorological organisation.

Although the various measures of retrenchment were so adopted as to create a minimum loss in establishment, still the toll of staff has amounted to as many as 5 gazetted officers, 32 ministerial officers and 20 chaprasis, printers and daftries. These retrenchments have also necessitated certain internal re-arrangements. For example, the Calcutta Office, having to take over forecasting responsibilities for a greatly extended air-route, had to be relieved of some other work and consequently the responsibility for the purchase, test, repair and issue of meteorological instruments, etc., to all 3rd class observatories was transferred to the Instruments Section at Headquarters.

The problem of providing a more adequate aviation weather service with greatly restricted funds has received much attention. It is believed that a partial solution has been found in connection with the opening of new radio stations along the air-route, which were ordered and begun before the retrenchment campaign started and which do seem to provide an opportunity to start a system for the exchange of current weather reports between stations along the air route itself. A scheme for this purpose was drawn up after consultation with the Directors of Wireless and of Civil Aviation and was put into force on the 15th June 1932.

Amidst the additional work and worry of retrenchment, the normal activities of the department were continued as efficiently as was practicable under the circumstances. Warnings for cyclones, storms, depressions and squally weather and for heavy rainfall were issued as usual from Poona and Calcutta. The forecasting offices at Karachi, Delhi, Calcutta and Rangoon supplied weather reports and forecasts to aviators. As indicated in the previous report, the Meteorological Department also helps private flying in this country by giving the necessary training in meteorology to candidates for pilots' licences, which, according to International practice, require a certain proficiency in Meteorology; a number of such candidates were trained and examined in the departmental centres at Delhi, Karachi, Bombay and Calcutta. The importance of this training both to the pilots and to the department is considerable, because the pilots are enabled to understand the meteorological organisation better, and appreciate more fully the weather charts, the forecasts and the general meteorological facilities and at the same time the department's services become more efficiently utilised. It is therefore unfortunate that two of the centres where such training has been given have had to be closed as a result of retrenchment, while at the other centres increasing work and limited staff are making it more and more difficult to arrange courses of training. Seismological and magnetic observations at Bombay, time services at Calcutta and Madras, the weather reports at different centres, compilation and tabulation of climatological data, the ex-

ploring of the upper air by means of routine pilot balloon ascents and periodical sounding balloon ascents, solar observations at Kodaikanal—all these activities continued, as in former years, though with some restrictions imposed by the financial cuts. The scheme for the creation of a new branch of agricultural meteorology, to be financed by the Imperial Council of Agricultural Research, was held back on account of the retrenchment campaign, and before the end of the year it was decided that the branch, if started, would be on a much-trimmed and very modest scale.

On the scientific side of the department, the year was marked by a fair amount of progress. At Agra and Allahabad, about 160 sounding balloon ascents were made, a number of instruments penetrating to heights between 12 and 17 miles. A method of launching balloons at night with electrically illuminated tails was evolved and the experiments were successful up to the maximum height of about 4 miles to which a balloon could be followed. For the use of aviators it is important to be able to determine the height of the base of low clouds, and experiments were made with different kinds of searchlights to determine these heights at night-time. A variety of subjects, such as characteristics of the tropopause and the troposphere, thunderstorms in the Peninsula during the pre-monsoon months, inversions in the upper air, the cold wave of 1929, the general circulation of upper air at high levels over India and the neighbouring seas, the nor'westers in Bengal and duststorms at Agra were tackled. Assistance was given, as in former years, to the researches of Prof. K. C. Mehta on the transport of the spores of cereal rust by upper winds. At Bombay, comprehensive observations were undertaken on atmospheric electricity. A number of post-graduate students were working under the direction of the Meteorologist there on various research problems, some of which were completed and some were being pursued, for example, on evaporation and its measurement, on the influence of temperature on the size of cloud particles, on the charges carried by individual drops of rainfall, on "Oberbeck's vortices", on discontinuous fluid motion, on a type of horizontal and vertical seismograph with hydraulic magnification and damping, and on the disturbance of pressure at different depths of a liquid due to surface waves. At Calcutta, attempts were made to develop certain new types of meteorological instruments for the indication of pressure, temperature and inversion layers in the upper atmosphere. The instruments are based on very simple physical principles, have been used successfully at Calcutta and are cheaper than the existing standard instruments.

At the Headquarters in Poona, partly with the co-operation of research students, several investigations were made on the meteorological conditions on the Ghats before and during the monsoon; on upper air conditions in normal and disturbed weather, on solar and sky radiation, zodiacal light and the light of the moonlit night sky; on statistics and their application to seasonal forecasting and on the sizes of raindrops and cloud particles. The scientific activities of the individual members of the department can, to some extent, be judged by the number of papers contributed by them to scientific journals. Of these, a Memoir and about 20 Scientific Notes were published while several papers were communicated to foreign journals. Inasmuch as a great deal of the research work is carried out in the mornings or evenings, outside the routine office hours, the amount and the quality of the output says much for the keenness and scientific ability of the staff.

Marine Meteorology—Storm Warnings.

The system of storm warnings for ports and shipping.—There has been no change in the system from that described in the last year's report. Warnings for the Bay of Bengal area were issued from the Calcutta Meteorological Office and those for the Arabian Sea area from the Poona Meteorological Office. The number of ports in the warning list was 37 on the west coast of India and 28 on the Bay of Bengal. In addition to the sea ports, there were 8 river ports, 13 river police stations and 44 district police stations on the Calcutta warning list. The latest weather information was supplied, as usual, to shipping at sea by means of weather bulletins issued regularly twice daily from the coastal radio stations and more frequently, sometimes as often as six times a day, when the weather situation demanded it. The total number of weather bulletins and warning messages issued during the year was over 13,500.

Services to ports around the Bay of Bengal.—Warnings were issued for 56 periods of disturbed or suspicious weather. Out of these, on 5 occasions the disturbances developed into storms of which the most interesting was the one that occurred between the 22nd and 24th December in the southwest of the Bay.

With a strengthening of the northeast monsoon, conditions had become markedly unsettled in the southwest Bay on the morning of the 21st December, and rough seas, squally weather and rain were reported from most of the ships off the east coast of Ceylon. The unsettled conditions intensified in the course of that day and a deep depression had formed with centre near Lat. 7°N., Long. 83°E. on the 22nd morning. The depression rapidly intensified into a storm by noon of the same day. In the next 24 hours the storm became severe. S.S. " Surada " on her way from Colombo to Madras was caught in the storm and experienced on the 22nd-23rd winds up to whole gale from an E-ly to NE-ly direction and violent rain-squalls with rough seas. Madras, which was about 400 miles away from the centre of the storm, also experienced an NNE gale (about 40 m.p.h.) in the early hours of the 22nd and occasional squalls during the day ; the sea was very rough inside the harbour and " tremendous " outside it. S.S. " Ethiopia " could not leave Madras harbour for Rangoon till the 25th on account of frequent heavy rain-squalls.

On the 23rd morning, the storm was passing into the Palk Strait and on the same afternoon it was located about 50 miles southeast of Negapatam, where an NNE gale with high sea was experienced at 15 hrs. The storm remained practically stationary there till the morning of the 24th when moving slowly in a NW-ly direction it began to weaken. It crossed the coast at about 17 hrs. on the 24th to the south of Negapatam and filled up rapidly over southeast Madras during the next day.

The Port Officer at Pamban thus described the weather between 21st and 23rd December 1931 :—

" Severe gale of wind and very rough seas prevailed on the 22nd from 5 P.M. The weather was stormy with drizzling rain, heavy squalls and very rough seas on the 23rd from 6 A.M. to 6 P.M. The weather moderated after 6 P.M. on the 23rd."

The storm caused fairly widespread rain with locally very heavy falls in southeast Madras between the 20th and 24th, some of the notable falls being Vedaranniyam 12″ on the 23rd and 14″ on the next day and Negapatam 14″ and Tiruppundi 15″ on the 24th. The heavy rain was responsible for breaches in the railways and telegraph lines in southeast Madras.

The above storm occurred shortly after the retrenchment steps began to take effect and shortly after the abolition of the Madras Weather Report, when the local interests were missing that report. In connection with the warnings issued for the storm, the Madras Port Trust authorities complained to the Madras Government and through them to the Government of India that insufficient notice of the storm's probable formation had been received from Calcutta and that the want of the Madras Daily Weather Report had led to delay in giving warning to ships in the Madras Harbour to raise steam and prepare for bad weather. In consequence, considerable inconvenience was stated to have been felt in manœuvring a steamer from the Quay to another berth in the Harbour ; also, while the steamer was at the Quay, six coolies engaged in discharging her cargo had been washed into the Harbour and some injured. The Madras Port Trust further stated that had the Daily Weather Report at Madras been continued these events would not have taken place. The complaint was investigated carefully. It was evident that the Port authorities, having for so long been accustomed to the Madras Daily Weather Report, felt handicapped by its absence and found it more difficult to appreciate fully the warning telegrams from Calcutta, when a local weather chart was not simultaneously available. It appeared also that there existed some misunderstanding of the arrangements both before and after the abolition of the Madras Daily Weather Report. As far as the available information allowed, the Calcutta Office had warned satisfactorily for this storm, which formed very far south in the Bay, intensified quickly and caused very squally weather at Madras when the barometric centre was still 400 miles distant. As an indirect result of this correspondence it was decided for the benefit of the Madras Government to send telegraphic copies of warning messages from Calcutta direct to that Government in addition to the Madras Port authorities.

The other 28 Port Officers who sent in remarks on the work of the year expressed satisfaction with the warnings received by them.

Services to Arabian Sea-ports.—Warnings for disturbed or squally weather were issued on 13 occasions, of which the most important was the depression from the 9th to 14th December. Thirty Port Officers sent annual returns regarding the warnings issued. Practically all of them expressed satisfaction with the system and with the warnings ; two offered minor criticisms which were given careful consideration.

Exchange of information with ships at Sea.—The chief sources of marine data are wireless weather messages from ships at sea and extracts from weather logs of ships calling at the principal ports on the Indian seaboard. The object of the system of radio messages from ships is to help in increasing the efficiency of cyclone warnings. The system, which was started in 1914, was suspended during the war but resumed in 1921. Since that year, there has been a steady increase in the use of this system by ships in Indian waters.

The following figures show the number of ships' messages from the Bay and the Arabian Sea during the year under report as well as the previous years since 1921.

Year.	Ships' messages.	Year.	Ships' messages.
1921-22	649	1927-28	4,835
1922-23	956	1928-29	4,342
1923-24	2,237	1929-30	4,635
1924-25	3,633	1930-31	5,869
1925-26	3,689	1931-32	6,971
1926-27	4,282		

Thus, the year under report shows a most gratifying increase. It is not possible to mention here every steamship that sent messages, but those that sent more than 40 messages during the year are listed below along with the number of messages received from each :—

Aungban	112	Haresfield	58
Arankola	99	Hosang	55
Angora	61	Havildar	53
Aronda	60	Homefield	71
Badarpur	287	Jaladuta	75
Binfield	87	Jalapalaka	183
Barala	65	Jalatarang	57
Beme	98	Jalavihar	48
British Emperor	50	Karagola	49
British Holly	45	Karapara	64
British Judge	46	Kutsang	44
Canara	57	Kumsang	70
Chilka	134	Masimpur	97
Chyebassa	47	Maharaja	49
Cocanada	79	Nizam	44
Cranfield	49	Nurjehan	50
Dara	86	Nawab	67
Ethiopia	109	Queda	40
Elephanta	41	Quiloa	43
Edavana	89	Rajula	156
Ekma	119	Rohna	60
Ellenga	59	Rajput	42
Erinpura	82	Shahjehan	58
Garada	49	Takliwa	115
Gurna	47	Winkfield	79
Gandara	76	Warora	46

The second principal source of marine data for purposes of study is the log extracts collected by clerks in Calcutta and Bombay and the other agencies mentioned below. The British India Steam Navigation Company, the Scindia Steam Navigation Company and the Asiatic Steam Navigation Company have standing arrangements with certain of their ships' captains to copy and despatch extracts from weather logs in two kinds of forms, which are supplied to them for use during ordinary weather and during disturbed weather, respectively. The Port authorities at Rangoon also continued to render help by allowing the observers of the Time Ball and Tidal Observatory of the

Port Commissioners to collect ships' data. Occasionally, in special cases of interesting disturbed weather, logs of steamers were collected at Madras and through the help of the Colombo Port authorities. A total of over three thousand logs was recorded during the year.

Inland Weather Warnings and Forecasts.

The majority of officers to whom warnings of heavy rain on land are issued from Poona and Calcutta were district officers and officers of the Irrigation, Railway and other departments. The number of officers on the warning list was 245, including 23 officers of the Telegraph Department who generally required warnings for strong winds. In addition to these specific warnings to individual officers, the Daily Weather Telegraphic Summary contains heavy rainfall forecasts and its subscribers thus automatically get the warnings. The forecasts and warning messages issued from forecasting centres numbered 5,248, while 832 telegrams of heavy rainfall reports were sent direct to various officers by local meteorological observers. Reports on the working of the system were received from 159 officers who have expressed satisfaction with the warnings issued.

A few had points of minor criticism or suggestion on each of which, after careful consideration, suitable action was taken. Among the appreciatory remarks, the following may be mentioned :—

The Manager and Engineer-in-Chief, Port Department, Bhavnagar State—

"The information (about the disturbed weather) has been found to be very reliable and we have been able to deduce the local conditions from telegrams referring to conditions prevailing as far as Laccadives."

The Chief Officer, Ahmedabad Municipality—

"..... most of the warnings have, more or less, been followed by the actual occurrence of the events as predicted. The forecasts of the Meteorological Department have been found to be more accurate during the last monsoon than the previous years."

The Port Officer, Chandbali—

"With reference to my request for special weather reports on and from October 8th and 14th, owing to a steamer being ashore off Dhamra river, I have the honour to express my thanks and keen appreciation of the very useful information you supplied."

Sub-Divisional Officer, Belgaum—

"The warnings invariably reached me in good time to arrange a standby party of line staff in case of a breakdown."

Aviation Forecasts.—Until the abolition of the Delhi and Rangoon offices, the offices at Karachi, Delhi, Calcutta, Rangoon, Poona, Quetta and Peshawar took part in the supply of forecasts to aviators, the principal customers being the State Air Mail Service from Karachi to Delhi, the French and Dutch Air Mail Services, the Royal Air Force, members of Indian aero clubs and trans-continental fliers. On the abolition of the Delhi and Rangoon offices, the responsibility for the main trans-India route had to be divided between the Karachi and the Calcutta offices, thus giving each of these two offices an

air-route of about 2,000 miles to watch over. The Government of India informed the Secretary-General of the International Commission of Air Navigation that

they "regret that, as a result of retrenchment, its meteorological service will not be able to attain the meteorological standard recommended in Annexe G of that [International Air] Convention. The Meteorological Office at Karachi will provide weather reports for the air-route between Bushire on the Persian Gulf and Allahabad in northern India; and the Meteorological Office at Calcutta will provide the weather reports for the air-route from Allahabad to Victoria Point in south Burma. These great lengths of air-route combined with the limited staff of officers and limited number of daily weather reports, will allow the issue from these two offices of only two general reports and forecasts daily at about noon and 8 P.M. based upon the routine weather charts. Thus, though a completely adequate service according to present day standard cannot be maintained, a skeleton service for the whole route from the Persian Gulf to south Burma, will continue until such time as the improvement of financial conditions makes it possible to consider improvements in the meteorological service also."

The new arrangements are inherently unsuitable as permanent measures and the department is anxiously waiting for financially more propitious times to arrive, so that the whole meteorological organisation may be put on a sound basis. The forecasting centres, inspite of these handicaps, did all they could to meet the needs of aviators and it was encouraging for them to receive appreciatory messages from several sources, two extracts from which are given below :—

The General Secretary, Koninklijke Luchtvaart Maatschappij Voor Nederland En Kolonien N. V. Royal Dutch Air Line, in a letter of the 16th September 1931 to Meteorologist, Calcutta, wrote :—

"Our home-coming crews of the Amsterdam-Batavia route are always mentioning to us the great assistance and the thorough reliability of your meteorological service and it is a great pleasure to us to thank you very heartily for all the efficient help you are giving our company.

Your weather forecasts have always been of the utmost usefulness to our crews in their extremely difficult task of building up a regular and reliable service between Amsterdam and Batavia."

The Consular Agent for France to the Meteorologist, Karachi :—

"I have a cable from His Excellency the Governor General of Cochin-China requesting me on his behalf to compliment and thank you for the excellence of your weather reports especially with regard to flight of the French aviators Codos and Robeida who passed through Karachi last Friday."

The total number of aviation forecasts issued was about 3,302, out of which Karachi was responsible for 1,641, Delhi for 644, Rangoon for 290, Calcutta for 341, Poona for 50, Quetta for 191 and Peshawar for 145.

Offices and Observatories.

A list of the staff of the India Meteorological Department, as it stood on the last day of the year under review, is given in Appendix "A". The issuing of the third edition of the note on "Functions and Organisation of the India Meteorological Department", which is published annually by the Department of Industries and Labour early in the calendar year, was deferred in view of the important changes that were taking place or were about to take place on account of retrenchment. It is proposed to prepare the revised edition towards the end of 1932. Financial stringency necessitated the postponement of the fourth annual conference of departmental officers, which was due in July 1931, and the absence of

which was felt to have deprived the department of the benefit of discussions by the officers of various problems facing the department.

It was most gratifying to note that Mr. M. G. Subrahmanyam, the senior-most member of the Assistant Meteorologist's cadre, was the recipient of the title of Rao Bahadur in the King Emperor's Birthday Honours List. The Director-General (Dr. C. W. B. Normand) was nominated, during the year, a member of the Court of the Indian Institute of Science, Bangalore and later was appointed a Member of the Council of the same Institute for the period 1932-1935. Dr. A. L. Narayan of Kodaikanal Observatory was elected President of the Mathematics and Physics Section of the Indian Science Congress to be held in January 1933, the fifth member of the department to hold this position in 20 years. Mr. G. Chatterji and Dr. K. R. Ramanathan were nominated members on the International Commission for the Exploration of the Upper Air, Dr. B. N. Banerji a member of the International Commission on the application of Meteorology to Air Navigation and Mr. V. V. Sohoni a member of the International Commission on Maritime Meteorology.

Headquarters Office, Poona.—A brief review of the scientific work done in this office has already been mentioned amongst the chief features at the beginning of this report. On the scientific side a useful means of maintaining interest is the colloquium of which 12 meetings were held, the discussion at each meeting being opened by a member of the staff who took as his subject either his own original work or a recent important paper published in a foreign journal. At a special meeting of the colloquium, the members and outside guests had the pleasure of listening to an address by Sir C. V. Raman. On the administrative side, the attention of the office as a whole was directed to find ways and means to satisfy the all-pressing needs of retrenchment.

(*a*) *General Section.*—This section is responsible for the administration of Headquarters and sub-offices and deals with budget and accounts, establishments, general registry and technical questions involving change of policy or fresh expenditure as well as the arrangements for the co-ordination of the technical work of the department. During the year, in addition to all these routine duties, the section had to tackle problems and give effect to decisions in connection with retrenchment and the resulting steps which involved a large amount of additional complicated work. The measures of retrenchment have already been described briefly under 'Chief features of the year' at the beginning of this report. Among the general matters that were dealt with by the section may be mentioned the discussion of meteorological arrangements in the event of the separation of Burma. Another matter that progressed rather slowly and with periodically suspended activity was the project for the inauguration of a new branch of agricultural meteorology under the auspices of the Imperial Council of Agricultural Research. Naturally, the financial stringency both delayed and threatened this scheme and at the end of the year a proposal to put a reduced project into force with only one gazetted officer and correspondingly smaller staff was awaiting sanction from Government. Towards the end of the year a new scheme for the transmission of current weather information for the benefit of pilots was evolved. Under this arrangement, places where there are wireless stations, become the important observatories along the main air-route, and whole-time observers were being transferred to them. With the assistance

of the chain of wireless stations, arrangements were made to transmit, as a routine measure as well as on special occasions, current weather information from station to station for the benefit of air pilots. The scheme involved practically no new expenditure. Among minor administrative matters may be mentioned the arrangements made for the reservation of sites for observatories in Burma, the introduction of the use of the credit-note system for this department's railway transport transactions (practically wholly needed by the upper air organisation) and arrangements with the Persian Telegraph Administration for the acceptance of weather telegrams without prepayment.

(*b*) *Weather Section.*—The functions of this section have been partly outlined in previous pages dealing with storm and heavy rain warnings. The section is responsible for the issue of weather telegrams, the daily, weekly and monthly weather reports and for the preparation of portions in the Annual Summary of the India Weather Review relating to weather. New working charts on a scale 1 : 10,000,000 larger as well as of much greater extent than those in former use, were introduced. Special help was given to some long trans-continental flights of French aviators, including the flight of the Colonial Minister, by arranging synoptic broadcasts from Karachi and Rangoon.

For some years it has been recognised that the one chart a day, which the Poona Office prepares, is not sufficient for a proper study of weather changes. There are few meteorological services, if any, that prepare only one chart daily ; all services known to this department prepare at least two, most three and some four and even more charts a day. All interests who make use of the Indian weather reports and warnings, including the newspaper-reading public, would be profited both directly and indirectly by the anticipated improvement in forecasts and warnings. A proposal to inaugurate a second afternoon chart was submitted in the preceding year but had to be held up owing to the unfavourable financial situation. During the year under report, the matter had to be reviewed departmentally once more, because of the probability of an early southward extension of air services to Bombay and Madras, a route, which, in the weather over the Ghats in the height of the monsoon, constitutes a severe obstacle to regular operation. The Poona Office has never been organised to meet the weather needs of a regular air-service for southern India, and even the provision of a second afternoon chart would still fall short of enabling the department to provide the minimum weather service recommended under the International Air Convention.

(*c*) *Observatories Section.*—This section, as usual, administered and arranged for the inspection of departmental observatories not under charge of sub-offices. Consequent upon the abolition of the Rangoon Meteorological Office, arrangement, about transferring the control of observatories under Rangoon Office to Calcutta had to be made. Further re-arrangements of control of observatories consequent upon the abolition of Delhi Office and the extension of the sphere of Karachi Office were also under consideration. Inspection of observatories had to be considerably restricted on account of financial stringency. Only 23 observatories were inspected as against 100 in the previous year. Three second class observatories and three fourth class observatories were opened and one observatory each of second, third and fourth class was closed. In pursuance of the recommendation of the Royal Commission on Agriculture, the Bombay Agricultural Department wished to

start second order meteorological stations at three of their agricultural farms, and this department undertook to loan the necessary instruments and to undertake the technical supervision of these observatories. Technical notes for departmental use consisting of general instructions for the inspection of observatories and on the comparison of observatory barometers with Fortin barometers used as touring standards were drawn up and some progress was made in the compilation of a revised edition of a long-felt need, the Handbook of Observatories.

(*d*) *Instruments Section.*—Over and above the existing charge of self-recording and special instruments, the section took over, from the 1st January 1932, the responsibility for the purchase, test, standardisation, repair and issue of the ordinary meteorological instruments that are issued to third class observatories, as well as the distribution of stationery and forms to all such observatories. These duties were for over fifty years undertaken by the Alipore Observatory and their transfer to Poona was a result of the reorganisation connected with retrenchment. During the year 295 special and self-recording and other meteorological instruments were issued to observatories, and 23 instruments issued on loan. 162 instruments were tested and 167 repaired. The equipment of all first class observatories with a standard set of up-to-date autographic instruments was completed. At the request of the Vizagapatam harbour authorities, steps were taken to instal one anemograph at the site of the pilot balloon observatory at that station. Along with the work of remodelling dial pattern anemometers into the I. M. D. cyclometer type, the manufacture of wind-vanes of the improved pattern was taken up and 60 of them completed. The observatories at Bombay, Agra, Calcutta and Kodaikanal were each equipped with an up-to-date seismograph recording photographically, and two components of Omori-Ewing seismograph released from two of these offices were handed over to the Physics Department of the University of Rangoon for installation there. Arrangements were made for the disposal of the instrument stock at Rangoon, Delhi and Madras which were closed down from the beginning of 1932 owing to retrenchment. Work on the fine weather changes of the potential due to atmospheric electricity was continued throughout the year. Steps were taken to equip five observatories of the department with searchlights and cloud altimeters for the determination of the heights of the base of low clouds. Arrangements were set on foot for obtaining a complete set of autographic records of the various meteorological elements at the high-level stations of Quetta and Kodaikanal. It is felt that in regard to workshop facilities, this section is still considerably handicapped, but proposals for the improvement of the situation have necessarily to be deferred, until times are financially more propitious.

(*e*) *Marine Section.*—The usual duties of the section were carried out satisfactorily. These consisted of co-ordinating the work of collection, examination and study of ships' weather logs and of maintaining contact with shipping interests in Bombay. The existing code for radio weather messages from ships in Indian waters was revised and replaced by the new "Indian Ships' Weather Code". Arrangements were made for the reception of wireless weather messages from British "A" and "B" selected ships. The section, as in previous year, co-operated with the authorities of the I. M. M.T.S. Dufferin in the meteorological training of the cadets, and helped by lectures

on meteorological subjects, by examining essays of cadets and by preparing a set of weather chart exercises for them.

(*f*) *Upper Air Section.*—Sounding balloon work was carried on regularly at Poona. During the monsoon months, similar work was done also at Hyderabad with the kind co-operation of the Director of the Nizamiah Observatory. During the year under report, 122 meteorographs were let off from Poona and Hyderabad together, 64 of which were received back. Observations of upper air temperatures and humidities obtained from ascents of Royal Air Force aeroplanes at Peshawar, Quetta and Karachi continued to be worked out and the results from January 1929 were included in the monthly volumes of "Upper Air Data". A pamphlet on the organisation for the supply of meteorological information to aviators was prepared and was in press at the end of the year. To get some idea of the meteorological conditions over the Ghats before and during the monsoon, a temporary first class observatory was run at Khandala from the beginning of May till the end of September 1931 with one of the research scholars, as observer. The International Commissions on Upper Air and Polar Year requested this Department to co-operate in the organisation of widespread and uniform observations of meteorological, magnetic, electrical and radiation phenomena during the period of the second "polar year", *viz.*, 1st August 1932 to 31st August 1933. Besides arranging for whatever can be done within the department with our present financial restrictions, such other bodies or workers in India as are in a position to further the objects of this world-wide enterprise were requested to do so. Besides further work on the study of upper air conditions in normal and disturbed weather, investigations were also carried out on solar and sky radiation, on zodiacal light and on the light of the moonless night sky. Some of the investigations were carried out by or with the assistance of paid or voluntary research scholars. Experience has proved how valuable research scholars are in such work and it was a great pity that retrenchment took the toll of the two scholarships that were sanctioned by Government as an experimental measure for three years. But for the present financial stringency, the department would have urged their continuance and possibly asked for an addition to their number.

(*g*) *Library Section.*—This section is responsible for the library, the departmental publications (other than daily or weekly), the supply of meteorological and cognate information in reply to inquiries, the seasonal forecasts and the statistical studies relative to them.

The number of books, pamphlets and periodicals either purchased or received in exchange for the publications of the department or as complimentary copies, was 799. The number of addresses on the free distribution list of the departmental publications was 359 at the end of the year. One Memoir and 20 Scientific Notes were published departmentally while several papers were contributed by members of the staff to foreign journals. Appendix "B" gives the publications issued during the year as well as the papers contributed by members of the staff to non-departmental journals. About 300 inquiries for climatological or meteorological information were answered during the year. Statistical studies included the "method of coincidences" for calculating correlations quickly and the application of the "performance" test to the forecasting formulæ.

The Climatological Branch of the Section, as usual, scrutinised the accuracy of records of surface meteorological data, prepared meteorological tables for the routine publications of the department and supplied periodical reports and data to various Government and public bodies. Five-day normals of maximum and minimum temperatures, accumulated rainfall, pressure and relative humidity were printed. Certain stations, the available normals of which were based on data for a small number of years were revised by inclusion of 10 years' additional data up to 1930. Pressure, mean temperature and rainfall data of 45 stations in India for the period 1921 to 1930 were supplied to the Smithsonian Institute, U. S. A., for inclusion in their collection of "World Weather Records". The Monthly Weather Report was remodelled to include data from all reporting stations and the dates of occurrence of extremes of temperature and heaviest rainfall. As a consequence of the reorganisation after retrenchment, arrangements were completed for the despatch of data for the Monthly Weather Report from Calcutta and Karachi meteorological offices for stations under the administrative control of those offices.

Upper Air Observatory, Agra.—This Observatory administers all the pilot balloon stations of the department except those at other regional centres such as Karachi, Calcutta or Poona where the staffs are under the charge of local officers. As a part of the retrenchment scheme of the department several pilot balloon stations had to be abandoned and consequently corresponding observer-staff had to be discharged. The station at Aden was closed from 1st March 1932 and the opening of Seychelles, Khanpur and Toungoo had to be abandoned. The opening of a few other stations in Burma and Assam had also to be either deferred or suspended. There were in all 31 pilot balloon stations under the technical control of this observatory out of which 20 only were under its administrative control. Regarding the scientific activities at the observatory mention has been made under 'Chief features'. In all 158 sounding balloons were released including 30 from Allahabad. 116 were retrieved, including 28 belonging to the batch released in the previous year and it was found that a number of them had penetrated the stratosphere as high as 12 to 17 miles. The Chatterjee temperature indicators designed for determining different levels of temperature in the free air referred to in the last year's report were let off regularly at Alipore throughout the year under review and at Agra and Bombay until the beginning of December 1931, after which owing to financial stringency they had to be discontinued. The total output of hydrogen, in spite of the retrenchment of some stations, was approximately 184,000 c.ft., as compared with 205,000 in the previous year. The original equipment was not designed for continuous operation at this output; and an electrolyser transformer, three motor generators and two compressors were purchased during the year to cope with the larger demands of recent years. Also, an agreement for a period of five years was entered into by Government with the Agra Electric Supply Company for supply of current for hydrogen-making and for the new buildings. Steps were being taken for the installation of the new plant.

Colaba and Alibag Observatories.—The routine meteorological, seismological, magnetic and time work at Colaba and Alibag Observatories was carried on as in previous years. The Colaba Observatory is the departmental centre for seismological studies. Data were supplied from Alibag records

to the Director, Geodetic Survey in connection with the reduction of observations at the Survey of India magnetic repeat stations. As usual, the observatory carried out the time service for the Port of Bombay efficiently and also looked after a large number of chronometers and watches belonging to the R. I. M. and R. N. ships. Considerable headway was made in clearing up the arrears of routine publications. The observatory volumes for 1927 and 1928 were published and that for 1929 was in the stage of final proof while the manuscripts for the 1930 volume were complete. The method of preparation of the data for these annual volumes was reorganised in a way that should prevent the growth of any arrears in future.

The observatory continued to issue a weather summary, the material for which is telephoned from the Poona Office. The summary covers the principal features of the daily weather over western India and takes the place of the old Bombay Daily Weather Report, which was abolished on the transfer of the Headquarters Office to Poona. The issue of this summary is limited to the period May to November inclusive.

Comprehensive observations of atmospheric electricity were undertaken during the year by means of a photographic electrograph. With the help of a number of post-graduate students several investigations were being carried out, on evaporation, on the sizes of cloud particles in a condensation chamber, on types of discontinuous fluid motion under different thermal conditions, on a type of horizontal and vertical seismograph with hydraulic magnification and damping, and on the disturbance of pressure at different depths of a liquid due to surface waves of various types and wave lengths. The last problem is of considerable importance in the theory of microseisms. Work was also undertaken on the size and intensity of charges carried by individual drops of rain and on the artificial vibrations of ground produced by the dropping of a known weight from a known height. An apparatus was being set up for recording lightning and thunder at night, the former with the help of a photo-electric cell and the latter with that of a carbon-microphone, both phenomena being intended to be recorded by a single galvanometer on the same sheet of paper.

Alipore Observatory and Meteorological Office, Calcutta.—The principal functions of storm warnings, heavy rainfall warnings for the Bay of Bengal and the surrounding areas, and the issuing of forecasts to aviators were carried out as satisfactorily as was possible under the limitations laid down by retrenchment. As a result of the closing down of the Delhi and Rangoon offices, the Calcutta Office had to undertake responsibility for the air-route between Allahabad and Victoria Point. As a result of the necessary rearrangements in work, the Alipore Office was relieved of the responsibility for the test, standardization and supply of instruments to observatories, this work being transferred to the Instruments Section of the Poona Office. The other meteorological, seismological and time determination duties of the observatory were carried on satisfactorily. Special weather forecasts and reports were sent to the Engineer-in-Chief, Bally Construction during the period of the construction of the bridge. The Alipore Office also administers observatories in northeast India to which, after the closure of the Rangoon Office, were added those in Burma. A few second class observatories were started and about half a dozen existing observatories were raised to the second class. Four stations commenced determination of the height of the base of

the low clouds as well as upper air temperature by means of temperature indicator flights. At Alipore a Benndorf Electrometer was installed. The investigation of nor'westers for a third season, which was originally contemplated, had to be deferred owing to the financial stringency, but an investigation on the mechanism of nor'westers was continued with the help of material collected in past years.

Meteorological Office, Karachi.—The principal function of this office is the supply of aviation forecasts to the Imperial Airways Mails, the Indian State Air Mail Service, the Dutch and French Air Mail Services, which, during the year, became weekly from October 1931, instead of fortnightly, the Royal Air Force, the Flying Boat Squadrons of Basra and other fliers—trans-continental as well as local. For its daily charts, it used to receive synoptic broadcasts containing 06·00 and 12·00 G. M. T. observations from Iraq stations. As a result of retrenchment in the department, the arrangements in Karachi Office were affected to a considerable extent. It ceased to receive synoptic broadcast from Ismailia throughout the year and from Abu Zabal during six months of the year. It stopped the issue of short-wave synoptic broadcasts from Karachi as well as the temperature investigations on the 200-foot mast. Further, on account of the abolition of the Delhi Meteorological Office from 1st January 1932, Karachi Office had to undertake the additional responsibility of a portion of the route formerly served by the Delhi Office, the total area of responsibility now extending from the Persian Gulf to Allahabad. It was also contemplated to transfer, with the provision of additional staff of one Professional Assistant and five clerks, the technical and administrative control of observatories in east Rajputana, west United Provinces, the Punjab, Baluchistan and North-West Frontier Province from the Poona to the Karachi Office. To enable the office to forecast for its extended area of responsibility, arrangements were made for the reception at Karachi of some 55 additional observation messages daily from surface and pilot balloon stations, partly for the morning and partly for the evening charts. Arrangements were made at the request of the Air Officer Commanding, Iraq for the supply of copies of observations from the department's reporting stations over the Persian Gulf and Mekran for the use of the Meteorological Officer, Iraq. The Karachi Office also functions as a main supply centre for synoptic and other observational data for the Royal Air Force forecasting centres at Quetta and Peshawar. The total number of synoptic weather reports, upper air observations and forecasts, forwarded to Royal Air Force at Drigh Road, either for local use or for onward transmission to other Royal Air Force centres, was 3,973. The air-craft depôt continued to render valuable assistance by supplying temperature and pressure data up to about 10,000 feet, the total number of such aeroplane flights during the year being 183. In connection with the projected use of aeroplanes by the Imperial Airways on the Basra-Bahrein-Muscat-Gwador-Karachi section of the air-route, data about upper winds at Bahrein, Jask and frequency of northeast winds at Manora were supplied to the Meteorological Officer, Heliopolis. As usual meteorological information was supplied to the public, including officials of the agricultural department, of the Karachi Port, newspapers, engineers, municipality, the railways and so on, while a number of warnings were also issued to various bodies. A Karachi Daily Weather Report was started from 11th February 1932. As there was no prospect of meteorological buildings for the office and observatory

being taken up on account of financial stringency and the old rented buildings were too small, the office was shifted to a new rented house at 8/3, Civil Lines, Victoria Road, on 1st June 1931. Six months later, a telegraph office was started by the telegraph department in the office building to facilitate the meteorological work. The office continued to administer about 30 observatories within the area Persia to west Rajputana and about 10 observatories were inspected. Prof. A. R. Normand of Wilson College, Bombay on his way through Persia very kindly volunteered to inspect the observatories at Meshed, Ispahan and Teheran and his assistance is gratefully acknowledged. In connection with accidents to French and Imperial Airways machines, enquiries were made regarding the weather situation at the times of the accidents and, although it was shewn that there was no defect in the meteorological arrangements, which were as complete as the existing organisation allowed, the enquiries helped to demonstrate the need for more frequent observations from stations on air-routes.

Kodaikanal Observatory.—The solar and astronomical researches during the calendar year 1931, have been summarised in the Annual Report of the Kodaikanal Observatory. The routine of the Observatory now includes, as mentioned in the last year's report, the tabulation of areas of Hα absorption markings and the periodical communication of daily character figures for solar activity according to Hα disc spectroheliograms to the Observatoire Fedéral, Zurich. Several schemes about buildings and construction were under consideration. One of them relates to the provision of municipal water supply to the Observatory and the neighbouring properties, which was receiving the attention of the Government of Madras, Kodaikanal Municipal Council and the Government of India : another related to the provision of septic tanks, etc., for the Observatory buildings and quarters : a third for the connection of electric supply to the Director's and the Assistant Director's quarters. Some improvements and extensions in the quarters for Observatory staff quarters were effected. The 8″ equatorial of the Madras Observatory and a Milne-Shaw seismograph were both received from Madras ; the latter is to replace the old Milne horizontal pendulum seismograph. A set of dyed fabrics received from the Wool Industry Association, Leeds, was being tested by exposure to sunlight to see the fading effect. Eight occasional staff meetings were held during the year for the discussion of scientific topics or papers.

Meteorological Office and Observatory, Madras.—This historic institution continued its functions of the publication of the Madras Daily Weather Report and the maintenance of time service to local shipping and through the inland telegraph system to the whole country, until it fell to the axe of retrenchment. The Daily Weather Report was stopped with effect from 1st November 1931 ; the function of transmitting time signals over the Indian telegraph system was transferred to the Meteorological Office, Alipore, Calcutta ; and the Observatory was ultimately reduced to the status of a pilot balloon station with effect from 1st March 1932. Thus an institution, which saw the light of day as far back as 1792, becomes after a varied career of usefulness an ordinary meteorological station. Its history was given in the Administration Report of the Department for 1925-26.

Meteorological Office, New Delhi.—The principal function of this office was to provide weather reports to the Karachi-Delhi Air Mails, to all aeroplanes on the Jodhpur-Gaya route and for other aviators including the Royal

Air Force for flights over central and parts of northwest India. For this purpose, the Office used to prepare two charts a day based on 8 hrs. local time and 17 hrs. I. S. T. observations. As a measure of retrenchment, the whole Office and Observatory was closed down with effect from 1st January 1932.

Meteorological Office, Rangoon.—The principal function of this office, located in the rented building at 17, Wingaba Road, was the issue of weather reports to the Dutch and French Air Mail Services, and other aviators along the Akyab-Rangoon-Victoria Point route. For the benefit of the local officials and newspapers, the office was also publishing a daily weather summary relating to Burma. The basis of the forecasting work was the weather chart prepared twice daily morning and evening. As a measure of retrenchment, this office was closed down from 1st January 1932.

Meteorological Office, Quetta.—The Royal Air Force Meteorological Officer, was replaced in 1930 by a temporary member of the Indian Meteorological Service. This officer continued in charge of the Quetta Office during the year under review, and issued to the Royal Air Force detailed local forecasts and warnings as well as a daily weather report for the area Baluchistan, Sind, and the Punjab. In addition to this, about 200 special route forecasts and weather reports were issued. Among other routine duties of the office were the conducting of the first class observatory and the collection of meteorological observations taken regularly by pilots in the Royal Air Force flying machines in that area.

Meteorological Office, Peshawar.—This office is in charge of the Royal Air Force Meteorological Officer, who is only technically under the control of the Director-General of Observatories. His functions are the supply of weather reports to the Royal Air Force comprising detailed local forecasts and warnings against heavy rainfall, etc., for the immediate neighbourhood of Peshawar, and the issue of route forecasts and special forecasts for Royal Air Force and other military units. This centre also undertakes the duties of a first class observatory and pilot balloon station, the collection of upper air temperature observations through the agency of Royal Air Force aeroplanes, as well as replies to all local enquiries.

Other Observatories.—The numbers of observatories of various classes are shown in the table below, which also gives the corresponding figures at the end of the previous year. For a description of classification of these observatories, the reader is referred to Appendix " C " of the Administration Report for 1930-31.

	On 31st March 1932.	On 31st March 1931.
I Class	12	14
II Class	160	153
III Class	82	85
IV Class	23	23
V Class	25	19
Non-departmental	59	54

The records of the non-departmental observatories were scrutinised by this department and in most cases utilised in the daily weather reports and other departmental publications. The importance of these observatories need

hardly be emphasised and the co-operation of the Indian States and other public bodies, who maintained them for the furtherance of the study of Indian meteorology, is much appreciated. Among these may be mentioned the Kingdom of Nepal and the States of Hyderabad, Kashmir, Mysore, Travancore Jaipur, Bhopal, Miraj, Ichalkaranji and Patiala, the municipalities of Murree, Mussooree and Coonoor and the Agricultural Departments of the Punjab and Bombay.

Rainfall Registration.

The rainfall data collected by the provincial rainfall organisations, for which the Director-General of Observatories is the consulting authority, are published in the provincial rainfall tables, which are collected and issued in a single volume for the whole of India by this department. The number of stations included in this organisation in the different provinces and the number inspected during the year, together with corresponding figures for the previous year, are given in the following tables. Considering the financial stringency it is gratifying to note that there has been no appreciable fall in the number of inspections, except in Kashmir where the floods in the valley were mainly responsible for the large decrease.

Rainfall Registration during 1931-32.

No.	Province.	No. of raingauges at the end of			No. of raingauges inspected.			Remarks regarding the condition of raingauges.
		1931-32.	1930-31.	Change.	1931-32.	1930-31.	Change.	
1	Burma . . .	218	214	+4	225*	216*	+9	Satisfactory.
2	Assam . . .	128	129	—1	121	113	+8	Satisfactory.
3	Bengal . . .	235	236	—1	203	206	—3	Good.
4	Bihar and Orissa .	301	298	+3	245	260	—15	Satisfactory.
5	United Provinces .	270	270	0	221	228	—7	Satisfactory.
6	Punjab . . .	195	‡194	+1	167	160	+7	Good.
7	Jammu and Kashmir	34	34	0	7	28	—21	Generally good.
8	North-West Frontier Province.	33	33	0	27	26	+1	Good.
9	Baluchistan . .	73	76	—3	66	53	+13	Good.
10	Bombay . .	307	303	+4	259	262	—3	Generally satisfactory.
10(*a*)	W. India States .	27	27	0	0	0	0	
10(*b*)	Baroda . . .	13	13	0	5	10	—5	Good.
11	Rajputana . .	182	†181	+1	171	167	+4	Generally good.
12	Central India .	121	†104	+17	92	84	+8	Generally good.
13	Central Provinces .	191	‡191	0	97§	96§	+1	Generally good.
13(*a*)	Berar . . .	42	42	0	38	42	—4	Generally good.
14	Hyderabad . .	57	54	+3	2	2	0	Generally good. (Improvements made).
15	Mysore . .	79	†78	+1	79	78	+1	Generally good.
16	Coorg . . .	9	9	0	9	6	+3	Good.
17	Madras . . .	514	510	+4	495	488	+7	Good.

* Including Meteorological observatories.
† Upto last year some raingauges, whose data are not published in the daily or monthly and annual rainfall statements, were included.
‡ Upto last year the raingauges under the Irrigation Department were not included in this number.
§ Excluding rainguages under Irrigation Department.

Heavy Rainfall Reports.—Heavy rainfall is often so very local that small unrepresented areas can have as much as 10 inches without the weather chart with the present network of daily reporting stations conveying the least suggestion of the local deluge. To obtain reports of such local heavy rain promptly for the Daily Weather Report, it was arranged 11 years ago that observers at the provincial raingauge stations should telegraph to forecasting centres falls of 5 inches or more. The number of such telegrams received during 1930-31 was 257 as compared with 233 in the previous year.

Snowfall Registration.—Information about the distribution and the time of occurrence of snowfall in the Himalayas and the Afghan mountain areas was on the whole tolerably complete and the thanks of the department are due to the various officers who collected and forwarded the reports.

Concluding Remarks.

The Meteorological Department owes a large part of its usefulness to the sympathetic assistance it receives from other departments. Officers of various Government departments help the meteorological work as Honorary Superintendents of Observatories or in other capacities. The Posts and Telegraphs Department assist this department in the rapid transmission of meteorological information particularly in connection with the warning services.

Weekly telegrams are received from April to October from the Director, Royal Alfred Observatory, Mauritius. These telegrams give valuable information of the weather conditions in the Indian Ocean, and the department is indebted to this observatory for the punctual transmission of the information.

The department is greatly indebted for important information on meteorological conditions prevailing before and during the southwest monsoon to the Controller, Physical Department, Cairo ; the Directors of the Observatories at Buenos Ayres, Santiago, the Astronomer Royal, Cape Town ; Director L'Observatoire Physique Central, Leningrad ; the Secretary, Friends' Industrial Mission, Banani Pemba, Zanzibar ; the Principal Medical Officer, Tanganyika Territory, Dar-es-Salaam ; the Commonwealth Meteorologist, Melbourne ; Director of Agriculture, Salisbury, Rhodesia ; Chief of the Weather Bureau, Washington. Thanks are due to the Director, Koninklijk Magnetisch und Meteorologisch Observatorium, Batavia, for similar information and also for the daily weather telegrams from Sabang in Sumatra during the cyclone months April, May and October to December.

Thanks are due to the Marine Superintendents of the British India Steam Navigation Company, the Scindia Steam Navigation Company, the Asiatic Steam Navigation Company, and the Burma Oil Company for continuing the arrangement under which many captains of their fleets send weather logs to this Department. Captain Philby, Principal Officer, Mercantile Marine Department, Bombay, Commander A. G. Kinch, Deputy Conservator of Port, Bombay, and Commander Norcock, Deputy Conservator of the Port of Calcutta, have been willing helpers of this department, for which it is grateful to them.

The department is indebted to the Government of His Exalted Highness the Nizam of Hyderabad for the help rendered in carrying on sounding and

pilot balloon work at the Nizamiah Observatory, and to the Governments of Mysore and Travancore for their co-operation by regular collection of pilot balloon data at Bangalore and Trivandrum, respectively.

Thanks are due to the Eastern Telegraph Company for charging this Department half the usual rates for the transmission of South American weather telegrams. Thanks are also due to the various pilots of the Imperial Airways Limited, for the supply of weather logs to this department; to the various ships' officers, who send their marine weather logs direct to this Department; to the Superintendent of the Colombo Observatory for the most useful help he has rendered from time to time in connection with storm warning work.

C. W. B. NORMAND,
Director-General of Observatories.

POONA :
The 5th September 1932.

APPENDIX A.

THE STAFF OF THE INDIA METEOROLOGICAL DEPARTMENT AS IT STOOD ON 31ST MARCH 1932.

METEOROLOGICAL OFFICE, POONA.

Director-General of Observatories :

C. W. B. Normand, M.A., D.Sc. (Edin.).

General Section.

Meteorologist	V. V. Sohoni, B.A. (Hons.), M.Sc. (Bombay).
Assistant Meteorologist	C. Ramaswamy, M.A. (Hons.) (Madras) (*Offg.*).
Superintendent	C. P. Venkataramier, M.A. (Madras) (on probation.)
Assistants	6.
Stenographers	4.
Cashier	1.
Clerks and typists	12.

Weather Section.

Meteorologist	S. Basu, M.Sc. (Allahabad).
Assistant Meteorologist	B. N. Desai, M.Sc. (Bombay), Ph.D. (Edin.), B.A., LL.B. (Bombay).
Assistants	2.
Clerks and Tabulators	12.
Draftsmen	5.

Observatories Section.

Meteorologist	K. J. Kabraji, B.A. (Hons.), B.Sc. (Bombay), M.Sc., Ph.D. (London).
Assistant	1.
Inspector of Observatories	1.
Clerks	2.

Marine Section.

Meteorologist	S. Basu, M.Sc. (Allahabad).
Assistant	1.
Clerk	1.

Instruments Section.

Meteorologist	J. M. Sil, B.A. (Calcutta), B.Sc. (Engg.) (Boston Tech.).
Assistant Meteorologist	S. Mal, M.Sc., Ph.D., D.I.C. (London) (on probation).
Assistants	2.
Clerks	5 (3 posts vacant).
Draftsman	1.
Senior Observers	3 (2 posts vacant).
Junior Observer	1.
Storekeeper	1.
Mechanics (temporary)	2.

Upper Air Section.

Meteorologist	S. K. Pramanik, M.Sc. (Lucknow), Ph.D. (London). D.I.C. (London).
Assistant Meteorologists	Barkat Ali, B.A., M.Sc. (Punjab).
	S. L. Malurkar, B.Sc. (Mysore), M.Sc. (Cantab.), (temporary).
Assistant	1.
Clerks	2.
Senior and Junior Observers	5 (including 3 Senior Observers of the establishment of Agra, temporarily transferred).

Library Section (including Climatology Section).

Meteorologist	S. R. Savur, M.A. (Madras), Ph.D. (London).
Assistant Meteorologist	V. Doraiswamy Iyer, B.A. (Madras).
Assistants	3.
Librarian	1.
Clerks	15.
Draftsmen	3.

UPPER AIR OBSERVATORY, AGRA.

Meteorologist-in-charge	G. Chatterjee, M.Sc. (Calcutta).
Meteorologist	N. K. Sur, D.Sc. (Allahabad).
Assistant Meteorologists	B. N. Sreenivasiah, M.Sc. (Calcutta).
	S. P. Venkiteshwaran, B.A. (Hons.) (Madras) (temporary).
	S. K. Das, M.Sc. (Dacca & London), D.I.C.
Superintendent	Babu Ram Samnol, B.A. (Punjab).
Mechanical Assistant	Chain Sukh.
Chief Observer	1.
Chief Computer	1.
Foreman	1.
Clerks or Observers (Permanent)	41 (at Agra).
Clerks or Observers (Permanent)	62 (Out-station staff).
Mechanics (temporary)	10.
Clerks and Observers (temporary)	9.
Enginemen (Permanent)	2.

COLABA AND ALIBAG OBSERVATORIES, BOMBAY.

Meteorologist	S. K. Banerji, M.Sc., D.Sc. (Calcutta).

At Colaba.

Head Clerk	P. A. Salvi, B.A., LL.B. (Bombay) (*Offg.*).
First Assistant	1.
Observers	6.
Cashier	1.
Marine Clerk	1.
Typist and Stenographer	1.

At Alibag.

Observers	2.

ALIPORE OBSERVATORY AND METEOROLOGICAL OFFICE, CALCUTTA.

Meteorologist	S. N. Sen, M.Sc. (Calcutta and London), Ph.D. (London).
Assistant Meteorologists	L. A. Ramdas, M.A., Ph.D. (Calcutta).
	A. K. Das, M.Sc. (Calcutta), D.Sc. (Paris).
	S. S. Lal, M.Sc. (Lucknow), D.I.C. (London), M.Sc. (London), (temporary).
Superintendent	K. P. Banerji, M.A. (Calcutta), (on leave).
	T. N. Mitra, B.A., B.L. (*Offg.*).
Professional Assistant	N. P. Chatterji, M.Sc. (Calcutta), (on probation).
Chief Observer	G. N. Mukherji, (on leave).
	B. B. Roy, M.Sc. (*Offg.*).
Meteorological Assistants	3 (1 post vacant).
Clerks (Upper Division)	4.
Clerks (Lower Division)	24.
Stenographer	1.
Draftsmen	3.
Observers	4.
Inspector of Observatories	1.

METEOROLOGICAL OFFICE, KARACHI.

Meteorologist	B. N. Banerji, M.Sc. (Allahabad), Ph.D. (Cantab.).
Assistant Meteorologists	P. R. Krishna Rao, B.Sc. (Mysore), (on leave).
	K. Das, M.Sc. (Punjab), Ph.D. (London).
	B. K. Roy, M.Sc. (Calcutta).
Professional Assistant	H. R. Puri, M.Sc. (Punjab).
Meteorological Assistant	1 (post vacant).
Chief Observer	1.
Head Clerk	1.
Inspector of Observatories	1.
Stenographer	1.
Senior Clerks or Observers	4.
Clerks or Observers	9.
Junior Clerks or Observers	2.
Temporary Clerks or Observers	1.
Observers (out stations)	3.

SOLAR PHYSICS OBSERVATORY, KODAIKANAL.

Director	K. R. Ramanathan, M.A., D.Sc. (Madras).
Assistant Director	A. L. Narayan, M.A., D.Sc. (Madras), F.I.P.
Assistants	3.
Recorders	4.
Mechanic	1.
Bookbinders	2.

METEOROLOGICAL OFFICE, No. 3 (INDIAN) WING, R.A.F., QUETTA.

Meteorologist	A. K. Roy, B.Sc. (Calcutta), B.A. (Oxon.) (temporary).
Senior Clerk	1.
Junior Clerks	3.

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Meteorological Officer (R.A.F.)	R. G. Veryard, Fl.-Lt.
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Junior Clerks and Observers	3.

LAHORE OBSERVATORY.

Chief Observer	1.
Observers	2.

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Clerks and Observers	3.

RESERVE METEOROLOGIST.

Meteorologist . . . . . S. C. Roy, M.Sc. (Calcutta), D.Sc. (London).

OFFICER ON LEAVE.

T. Royds, D.Sc. (London).

OFFICERS ON LEAVE PREPARATORY TO RETIREMENT.

Rao Bahadur M. G. Subrahmanyam, B.A. (Madras), LL.B. (Bombay).	Assistant Meteorologists.
Rao Saheb M. V. Unakar, B.A. (Bombay)	
A. A. Narayana Aiyar, B.A. (Madras).	
Khan Saheb Shamsul Haq.	Superintendent, Poona Office.

APPENDIX 'B.

PUBLICATIONS.

The following Departmental publications were issued or sent to press during the year :—

I.—*Periodical.*

1. Daily Weather Reports :
   - i. Indian Daily Weather Report (to date).
   - ii. Calcutta Daily Weather Report (to date).
   - iii. Delhi Daily Weather Report (to 31st December 1931*).
   - iv. Karachi Daily Weather Report (to date).
   - v. Madras Daily Weather Report (to 31st October 1931*).
2. Weekly Weather Report (to date).
3. Monthly Weather Report (to date).
4. India Weather Review, Annual Summary for 1930, in seven parts :
   - i. Introduction.
   - ii. Part A.—Summary of Weather and Rainfall.
   - iii. Part B.—Snowfall.
   - iv. Part C.—Storms and Depressions.
   - v. Part D.—Annual Tables.
   - vi. Part E.—Seismic Records.
   - vii. Part F.—Errata to Monthly Weather Reparts.
5. Daily Rainfall of India for 1928.
6. Monthly Rainfall of India for 1928.
7. Upper Air Data, 1930, in 14 parts :
   - i. Parts 1—12.—Pilot Balloon and Aeroplane Data for January—December.
   - ii. Part 13.—Monthly Means of Pilot Balloon Data and Monthly Frequencies of Clouds.
   - iii. Part 14.—Sounding Balloon Data.
8. Seasonal Memoranda :
   - i. Memorandum on the probable character of the weather in North-West India in January, February and March 1932.
   - ii. Statement of the rainfall and snowfall of North-West India in January, February and March 1931 and a comparison of the seasonal forecast with the actual precipitation.
   - iii. Memorandum regarding the probable amount of monsoon rainfall in 1931.
   - iv. Memorandum on the rainfall of June and July and the probable amount during August and September 1931.
   - v. Statement of the actual rainfall in the monsoon season, June to September 1931, and a comparison of the forecasts with the actual rainfall.
9. Magnetic, Meteorological and Seismographic Observations made at the Government Observatories, Bombay and Alibag, in the year 1927.

   Magnetic, Meteorological and Seismographic Observations made at the Government Observatories, Bombay and Alibag, in the year 1928, (with an Appendix relating to the Climatology of Bombay).
10. Report on the Administration of the Meteorological Department of the Government of India in 1930-31.
11. Annual Report of the Kodaikanal Observatory, 1931.

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* Publication stopped on the closing down of the respective Offices on account of the financial stringency.

II.—*Occasional.*

1. Memoirs of the India Meteorological Department :

Vol. XXV.—

Part VIII.—The Lunar Atmospheric Tide at Bombay (1873—1922), by S. K. Pramanik, M.Sc., Ph.D., D.I.C.

Part IX.—On Evaporation and its Measurement, by S. K. Banerji, D.Sc. and H. M. Wadia, M.Sc.

2. Scientific Notes :

Vol. III.—

No. 27.—A Study of Thunderstorms in Poona in 1930, by B. N. Desai, M.Sc., Ph.D., B.A., LL.B.

No. 28.—Horizontal Gradients of Pressure and Temperature in the Upper Atmosphere over India calculated from Pilot Balloon Winds, by A. Narayanan, M.A.

No. 29.—The Bengal Cyclone of September 1919, by V. Doraiswamy Iyer, B.A.

No. 30.—The structure of the Sea-Breeze at Poona, by K. R. Ramanathan, M.A., D.Sc.

Vol. IV—

No. 31.—The Lunar Atmospheric Tide at Kodaikanal and Periyakulam, by S. K. Pramanik, M.Sc., Ph.D., D.I.C., S. C. Chatterjee, B.Sc., and P. P. Joshi, B.Sc.

No. 32.—On the Relation between the Weather and the Variation of the normal Vertical Gradient of Temperature in N. W. India, by S. Atmanathan, M.A.

No. 33.—Temperature Changes in Calcutta Thunderstorms, by V. V. Sohoni, B.A., B.Sc.

No. 34.—A Study of Two Pre-Monsoon Storms in the Bay of Bengal and a Comparison of their Structure with that of the Bay Storms in the Winter Months, by K. R. Ramanathan, M.A., D.Sc. and H. C. Banerjee, M.Sc.

No. 35.—An Improved Method of sounding the Lower Layers of the Atmosphere, by G. Chatterjee, M.Sc.

No. 36.—Contrivances for lifting the Pens off the Recording Plate of the Dines' Balloon Meteorograph during its Descent, by G. Chatterjee, M.Sc. and P. M. Neogi, B.Sc.

No. 37.—The Seasonal Forecasting Formulae used in the India Meteorological Department, by S. R. Savur, M.A., Ph.D.

No. 38.—Rainfall of Siam, Its Normal Distribution and Relation to Indian Rainfall ; Possibility of forecasting Monsoon Rains, by V. Doraiswamy Iyer, B.A.

No. 39.—A Study of the Structure of the Bay Storm of November 1926, by Sobhag Mal, M.Sc., Ph.D., D.I.C. and B. N. Desai, M.Sc., Ph.D., B.A., LL.B.

No. 40.—The Katabatic Winds of Poona, by S. Atmanathan, M.A.

No. 41.—The Sea-Breeze at Karachi, by L. A. Ramdas, M.A., Ph.D.

No. 42.—A Discussion of Monthly Mean Values of Upper Air Temperatures and Humidities obtained from Aeroplane Ascents at Peshawar and Quetta, by A. Narayanan, M.A.

No. 43.—On the Extreme Dryness observed at Kodaikanal during the Winter Months, by S. L. Malurkar., M.Sc.

No. 44.—Thunderstorms in the Peninsula during the Pre-Monsoon Months April and May, by S. P. Venkiteshwaran, B.A. (Hons.).

No. 45.—The Method of Coincidences, or a Quick Method of determining the Approximate Value of a Simple Correlation Co-efficient, by S. R. Savur, M.A., Ph.D.

II.—*Occasional*—contd.

2. Scientific Notes—*contd.*
Vol. V—
No. 46.—On Solitary Gusts Associated with Reversals of Pressure Gradients, by S. Atmanathan, M.A.
No. 47.—Horizontal Atmospheric Visibility at Quetta, by A. K. Roy, B.A., B.Sc.
No. 48.—Some Characteristics of the Tropopause and Upper Troposphere over North-West India, by N. K. Sur, D.Sc.

3. Kodaikanal Observatory Bulletins :—
No. XC.—Summary of Prominence Observations for the first half of the year 1930.
No. XCI.—On the Spark Spectra of lead, by A. S. Rao, M.A.
No. XCII.—Summary of prominence observations for the second half of the year 1930.
No. XCIII.—Rotation of H_α dark markings near the equator compared with other disk phenomena, by G. V. Krishnaswami, M.A.
No. XCIV.—Summary of prominence observations for the first half of the year 1931.

4. Indian Ship's Weather Code, 1931.

5. Meteorological Organization in India for the Supply of Weather Information to Aviators.

The following papers or notes were contributed by members of the staff to extra-departmental journals :—

Normand, C. W. B.—
Recent Investigations on Structure and Movement of Tropical Storms in Indian Seas,—Gerlands Beiträge zur Geophysik, Vol. 34 (Köppen Bd. III), 1931, pp. 233—243.
Graphical Indication of Humidity in the Upper Air,—Nature, Vol. 128, October 3, 1931, p. 583.
Some Problems of Modern Meteorology, No. 6—Present Position of Seasonal Weather Forecasting,—Q. Journal of Roy. Met. Soc., Vol. 58, No. 243, January 1932, pp. 3—10.

Banerji, S. K.—
On Oberbeck's Vortices,—Philosophical Magazine, Vol. XI, May 1931, pp. 1057—1081.
The Electric Field of Overhead Thunderclouds,—Phil. Transactions of the Roy. Soc., Series A, Vol. 231, 1932, pp. 1—27.

Chatterjee, G.—
A Note on an apparatus for catching spores from the upper air,—The Indian Jour. of Agricultural Science, Vol. I, Part III, June 1931, pp. 306—308.
On Some instruments for Sounding the Lower Layers of the atmosphere,—Gerlands Beiträge zur Geophysik, Vol. 34 (Köppen Bd. III), 1931, pp. 252—263.

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The Bahrein Storm and some studies of Cold Wedges over the Persian Gulf,—Beit. zur Physik der Freien Atmosphäre, Band 19, (Bjerknes Festschrift) 1932, pp. 34—36.

Ramanathan, K. R.—
Effect of radiation on the equilibrium of the higher layers of the troposphere and the nature of the transition from troposphere to stratosphere,—Beit. zur Physik der Freien Atmosphäre, Band 18, 1932, pp. 196—208.

Ramanathan, K. R. and Narayana Iyer, A. A.—
Note on the existence of warm and cold Sectors in tropical cyclones,—Gerlands Beit. zur Geophysik, Vol. 35, 1932, pp. 66—67.

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Nocturnal Atmospheric Radiation at Poona, A Discussion of Measurements made during the period January 1930 to February 1931, Gerlands Beit. zur Geophysik, Vol. 35, 1932, pp. 68—81.

Kabraji, K. J.—

The Crystal structure of the Hydrates of Copper Formate, Part I, Copper Formate Tetrahydrate ; Part II, Copper Formate Dihydrate,—Indian Journal of Physics, Vol. VI, 1931, pp. 81—132.

Pramanik, S. K. (Chapman, S.,—and Topping, J.)—

The World Wide Oscillations of the atmosphere,—Gerlands Beiträge zur Geophysik, Band 33, (Köppen Bd. II), 1931, pp. 246—260.

Savur, S. R.—

A Simplified Method for calculating Periodicities,—Indian Journal of Physics, Vol. VI, Part VI, 1932, pp. 527—541.

A Simple method of determining the approximate value of a simple correlation co-efficient,—Q. Journal of the Roy. Met. Soc., Vol. 58, 1932, pp. 56—58.

Narayan, A. L.—

Fine Structure in the Arc Spectra of Indium and Thallium,—Nature, Vol. 128, October 17, 1931, p. 675.

Barkat Ali.—

A remarkable instance of Waves in an Anemograph Trace,—Q. Journal of the Roy. Met. Soc., Vol. 57, 1931, pp. 300—303.

Barkat Ali and Naqvi, S. N.—

Correlation between frost and the preceding meteorological conditions,—The Indian Journal of Agricultural Science, Vol. I, 1931, pp. 671—694.

Ramdas, L. A. and Malurkar, S. L.—

Surface Convection and the Distribution of Temperature near a Heated Surface,—Nature, Vol. 129, February 6, 1932, p. 201.

Ramdas, L. A. and Venkiteswaran, S. P.—

Spectrum of Glow-Worm,—Nature, Vol. 128, October 24, 1931, p. 726.

Desai, B. N.—

Condition of sparingly soluble substances in gelatine,—Nature, Vol. 128, 1931, p. 223.

Desai, B. N. (with Nabar, G. M.)—

Condition of silver chromate in gelatine hydrolysed and electrodialysed to different extents,—Nature, Vol. 127, 1931, p. 628.

Relation between charge and stability of colloidal gold,—Nature, Vol. 127, 1931, p. 666.

A note on the Liesegang rings of silver chromate in gelatine,—Jour. Indian Chemical Soc., Vol. 9, 1932, p. 141.

The influence of hydrolysed gelatine on the precipitation of silver chromate,—Trans. Faraday Soc., Vol. 28, 1932, p. 449.

Desai, B. N. (with Barve, P. M.)—

Coagulation of colloids by electrolytes, Nature, Vol. 128, 1931, p. 907.

Desai, B. N. (with Nabar, G. M. and Patel, A. M.)—

Studies in the influence of non-electrolytes containing different number of hydroxy groups on the precipitation of thorium hydroxide from solution of thorium nitrate on the addition of NaOH,—Kolloid. Zeits., Vol. 52, 1931, p. 173.

Mal, S., Basu, S., and Desai, B. N.—

Structure and Development of Temperature Inversions in the Atmosphere Nature,—Vol. 129, 1932, p. 97.

Malurkar, S. L. and Ramdas, L. A.—

Theory of Extremely High Lapse Rate of Temperature very near the Ground, Indian Journal of Physics, Vol. VI, Part VI, 1932, pp. 495—508.

Ramaswamy, C.—

Polarisation of the Raman Spectrum of Water,—Nature, Vol. 127, April 11, 1931, p. 558.

APPENDIX C.

ANNEX G. TO CONVENTION RELATING TO THE REGULATION OF AERIAL NAVIGATION.

Collection and Dissemination of Meteorological Information.

SECTION I.

Classification of Information.

The meteorological information necessary to aerial navigation referred to in Article 35 (*a*) of the Convention, may be divided, in a general way, into three categories, *viz.* :—

(*a*) Climatological information (1) which is based upon past meteorological records analysed and summarised to show the weather which is experienced in the long run at a given place or in a given area.

(*b*) Current information (2) which is based upon reports of observations transmitted to a central station by wireless, or ordinary telegraphy or telephony, and upon observations made at the centre itself. Such information gives a survey of the existing conditions at the observing stations. Current information may be divided into two categories, *viz.* :—

(1) Information necessary for the preparation of synoptic charts.

(2) Information necessary for the working of airways.

(*c*) Forecasts (3) which are statements of the meteorological conditions anticipated during a period of time or for an epoch of time subsequent to the time of their issue. There are two kinds of forecasts of importance for air navigation, *viz.* :—

(1) General forecasts relating to an extensive area and usually for a period of 24 to 36 hours.

(2) Detailed short period forecasts relating to airways.

SECTION II.

Exchange of Information.

A. * *Climatological information.*—1. The fundamental information as regards pressure, temperature, wind and weather, is furnished by the published monthly and annual summaries issued by the various meteorological services as far as possible in the form recommended by the International Meteorological Committee.

2. The following summaries, of great importance for aerial navigation, should be prepared for each month of the year by each Contracting State, from the observations made at a selection of meteorological stations. These summaries will show :—

(*a*) The frequency of occurrence at each station of the different degrees of horizontal visibility for at least three different times a day, one in the morning, one near midday and one in the late afternoon.

(*b*) The frequency of occurrence at each station of the different heights of base of cloud for the same times as those selected for visibility.

(*c*) The frequency of occurrence at each station of winds of different directions and speeds at the surface and at heights of 500, 1,000, 2,000 and 3,000 metres.

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* (1) Climatological information is required :—

(*a*) in connection with the selection of airways.

(*b*) for indicating the variation of the meteorological conditions affecting flight during the day and the year and with the place and altitude.

(*c*) for indicating the places at which stations should be established for furnishing current information.

(2) Current information is required :—

(*a*) for the guidance of aviation companies and for the pilots or navigators.

(*b*) for the meteorologists responsible for the preparation of forecasts.

(3) Forecasts are required for the guidance of aviation companies and for the pilots and navigators.

These summaries should be prepared in the forms and for the heights and limits shown in Appendix G-1 and should be exchanged through the International Commission for Air Navigation.

It is particularly important that these summaries should be prepared in those countries where no airway has yet been established, in order that concise climatological information may be available for the establishment of airways over these countries as the need for them arises.

3. Further, each Contracting State is recommended to publish a " guide " conceived on lines which are essentially practical for use by airmen, presenting in a very convenient form a synthesis of climatological information useful for air navigation. The guide should also contain a table giving a list of meteorological information at the disposal of airmen at different times in the different countries.

B. **Current information.*—1. The observations should be made at hours fixed by international agreement and should be collected at regional or national centres. The reports to be exchanged in connection with the preparation of synoptic charts should be issued by wireless telegraphy at times fixed by international agreement. The reports for use on airways should be issued by wireless telegraphy at times fixed mutually by the States concerned. The issues should be made in such a way that the reports may be available to the personnel of the aviation and meteorological services with the least possible delay, duplication or interference.

2. The reports should be drawn up, as far as possible, in the form and according to the codes specified by the International Meteorological Committee. The codes recommended at present are given in Appendix G-2. The symbolic form of the reports and the codes indicate the nature of the information required.

3. Current information specially supplied to aircraft in flight should be either in clear or in the abbreviated code given in Appendix G-3. If coded information is required by a meteorologist or a navigator on board an aircraft, it should be furnished, as far as possible, in one of the codes of Appendix G-2.

4. The exhibition of current information at aerodromes is dealt with in Section III below.

C. *Forecasts.*—The code for international exchange of short period forecasts on an airway appears in Appendix G-10. The period covered by such forecasts will depend upon the length of the flights to be made and upon the precision with which the meteorological services can foretell the weather: it is desirable that such period should be longer than the normal duration of the flight without landing.

Section III.

Exhibition and supply of meteorological information at aerodromes.

The following meteorological information will be made available:—

1. A synoptic chart showing the general meteorological situation over a wide area at the time of the latest synoptic observation (Appendix G-4).

2. Special forecasts of the weather at the surface and in the upper air along the different airways starting from the aerodrome. These forecasts will give prominence to phenomena affecting the safety of air navigation, such as thunderstorms, squalls, fog and the danger of ice formations at certain altitudes.

It is furthermore recommended that the forecasts which foreign services have transmitted in respect of the portion of the route above their territory should also be exhibited.

3. Warnings of sudden changes (Appendix G-7).

4. Upper wind observations made by stations situated along or in the vicinity of airways.

5. Current information given:—

(*a*) By one or more skeleton maps covering the area to the aerodromes to which flights are made without landing. The maps should give the visibility, clouds, weather, wind

* Please see footnote on page 31.

on the ground and upper wind. The information should be shown by suitable symbols (Appendix G-5).

(*b*) By tables according to the scheme shown in Appendix G-6.

6. Corrections to altimeter readings (Appendix G-9).

SECTION IV.

Meteorological organisation of international airways.

1. The meteorological information of greatest inportance for an international airway is necessarily information about the conditions which the aviator will experience in the course of his flight: it is therefore a meteorological forecast.

Information of existing or recent weather is useful primarily because it is an essential part of the basis on which a forecast is made.

Measures must be taken so that this information can at any time be transmitted to pilots in the air and be furnished for the guidance of the aviation personnel at aerodromes and of all directly interested.

In the supply of information to pilots and aviation personnel clear differentiation must be made between reports of existing weather and the weather which the pilot will experience: the latter must be supplied by forecasts.

In consequence the forecasts must be detailed and must include all the information affecting either the safety or the economy of the flight.

2. The forecasts and reports should contain, before anything else, information about the visibility, the cloud and its height (and thickness), the general state of the weather, the wind in the upper air and the wind at the surface.

3. In order to give adequate information of existing weather meteorological reporting stations should be established along and in proximity to an airway and particularly at places having special conditions of visibility and low cloud.

When an airway over a Contracting State passes close to another Contracting State without crossing it, the latter State shall co-operate, as far as possible, in the protection of such airway by furnishing special meteorological information relating to the region extending in principle to a distance from the airway equal to three-quarters of the distance normally flown without landing, on the portion in question of the airway.

4. Meteorologists should be stationed at aerodromes at reasonable intervals along an airway to supply to the aviation personnel current information and forecasts of conditions along the airway to the next aerodromes of the same class.

5. Exchange of information should be made promptly and as frequently as necessary having regard to the climate of the airway concerned and, as far as possible, in the codes indicated in Appendices G-2, G-7 and G-10. International exchange will normally be effected by wireless telegraphy, though the national centralisation of reports may be made by wireless, or ordinary, telegraphy or telephony or by a combination of these methods.

6. Reports of violent and sudden phenomena which threaten the safety of air navigation, such as thunderstorms, squalls, fogs, and reports of improvements of weather when the conditions have been such as to threaten the safety of air navigation, should be transmitted immediately to the aerodromes concerned and to aircraft in flight; these reports should be made not only from stations situated along an airway, but also from stations covering it at a distance equal in principle to one-half of the distance normally flown without landing. The transmission to aerodromes will be effected as far as possible in the code which appears in Appendix G-7. The transmission to aircraft will be made in clear.

7. Stations situated on or in proximity to mountains should make special observations of cloud and visibility. These observations should be transmitted according to the code of Appendix G-7.

8. To assist the aviation personnel in the ready interpretation of the reports, provision should be made for the exhibition of the information in a uniform manner in accordance with the provisions of Appendices G-4, G-5, G-6.

9. Arrangements should also be made for the issue to the aviation personnel at the principal aerodromes of information regarding the corrections to be applied, in consequence of the variations of barometric pressure, to the altimeter readings at various points along the airway as far as the next aerodrome to which flights are made without landing. Such information shall be issued in accordance with the provisions of Appendix G-9.

10. Arrangements should also be made for the exhibition, where necessary, of ground signals to indicate the meteorological conditions existing at other places along the airway. The code of Appendix G-8 and, as far as possible, the system of panels referred to in that Appendix should be used.

NOTE.—The meteorological information furnished under the provisions of this Annex should be given in units of the C. G. S. system or derived units.

MGIPO—M—VIII-3-53—8-11-32—450.

NO—RM/33.

Report on the Administration of the Meteorological Department of the Government of India in 1932-33.

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Chukervertty, Chatterjee & Co., Ltd., 13, College Square, Calcutta.
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James Murray & Co., 12, Government Place, Calcutta. (For Meteorological Publications only.)
Ray Chaudhury & Co., 68-5, Ashutosh Mukherji Road, Calcutta.
Scientific Publishing Co., 9, Taltola Lane, Calcutta.
Chatterjee & Co., 3-1, Bacharam Chatterjee Lane, Calcutta.
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The Popular Book Depôt, Bombay.
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The Indian Army Book Depôt, Juliundur City, Daryaganj, Delhi.
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Rama Krishna & Sons, Booksellers, Anarkali, Lahore.
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The Proprietor, Punjab Sanskrit Book Depôt, Saidmitha Street, Lahore.
The Insurance Publicity Co., Ltd., Lahore.
The Punjab Religious Book Society, Lahore.
The Commercial Book Co., Lahore.
The University Book Agency, Kachari Road, Lahore.
Manager of the Imperial Book Depôt, 63, Chandni Chowk Street, Delhi.
J. M. Jaina & Bros., Delhi.
Fono Book Agency, New Delhi and Simla.
Oxford Book and Stationery Company, Delhi, Lahore, Simla, Meerut and Calcutta.
Mohanlal Dossabhai Shah, Rajkot.
Supdt., American Baptist Mission Press, Rangoon.
Burma Book Club, Ltd., Rangoon.
S. C. Talukdar, Proprietor, Students & Co., Cooch Behar.
The Manager, The Indian Book Shop, Benares City.
Nandkishore & Bros., Chowk, Benares City.
The Srivilliputtur Co-operative Trading Union, Ltd., Srivilliputtur (S. I. R.).
Raghunath Prasad & Sons, Patna City.
The Students Emporium, Patna.
K. L. Mathur & Bros., Guzri, Patna City.
Kamala Book Stores, Bankipore, Patna.
G. Banerjea & Bros., Ranchi.
M. C. Kothari, Raipura Road, Baroda.
B. Parikh & Co., Baroda.
The Hyderabad Book Depôt, Chaderghat, Hyderabad (Deccan).
S. Krishnaswamy & Co., Teppakulam P. O., Trichinopoly Fort.
Standard Book and Map Agency, Book Sellers and Publishers, Ballygunge.
Karnataka Publishing House, Bangalore City.
Bheema Sons, Fort, Bangalore City.
Superintendent, Bangalore Press, Lake View, Mysore Road, Bangalore City.

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Chief Features of the Year.

During the year under review the activities of the department were largely directed to various internal adjustments necessitated by the permanent cut of over 25 per cent in its budget. It was recognised that the department must be content to do less than is adequate in providing meteorological facilities for aviation and to make its service as

efficient as possible within the available grant. With the abolition of the Meteorological Offices at Delhi and Rangoon, the offices at Karachi and Calcutta had to share between them about 4,000 miles of the main international air route. The limited staff of officers and limited number of daily weather charts allowed the issue daily of two general weather reports and forecasts (at about noon and 8 P.M.) from two widely separated centres over this great length of air route. The additional special weather charts, which had been prepared at times of disturbed weather, could be prepared, owing to financial limitations, only on rare occasions ; and this naturally curtailed the efficiency of the weather service in its supply of information to individual aeroplanes. To compensate partly for the limited resources of the forecasting centres, an arrangement for the supply of current weather reports by wireless along the main Indian air route came into operation in June. Auxiliary centres where a meteorological assistant would receive weather reports from forecasting centres for transmission or elucidation to pilots were opened at principal landing places like Jodhpur, Allahabad, Akyab and Rangoon on the main air route. A scheme for the expansion of the current weather report system so as to include more frequent observations, warnings against adverse weather and also information about its improvement was drawn up and its introduction was under consideration.

While the post-retrenchment adjustments were in progress, a regular air-mail service between Karachi and Madras, *via* Bombay, was inaugurated with effect from the 15th October 1932, under an agreement between Government and Messrs. Tata Sons, Ltd., which indicated that Government would, if called upon to do so, provide to the Company such meteorological reports as might be available at the aerodromes used by the Company's aircraft. The question of provision of meteorological facilities in connection with this new air-route had, therefore, to be considered. The existing organisation allowed the issue of only one general weather report and forecast daily at noon from Poona for the section between Ahmedabad and Madras and of two reports daily from Karachi for the Karachi-Ahmedabad section. The Poona office has been attempting what perhaps no other meteorological office in the world is doing, namely to provide forecasts for aviation that are based upon weather charts prepared only once daily. Considering that a part of the route lying between Bombay and Poona is during the monsoon months among the most dangerous that exist anywhere, and that over some part or other of the route, disturbed weather may occur almost throughout the year on account of very active afternoon or evening thunderstorms, monsoon depressions, cold weather depressions, hot weather duststorms, cyclonic storms from the Bay of Bengal, etc., the existing organisation must be regarded as very inadequate. Accordingly three schemes were drawn up and placed before Government detailing (1) what was considered to be immediately necessary, (2) what was necessary to bring southern India meteorologically into line with the skeleton weather service now maintained on the international air route over northern India and Burma, and (3) what was necessary to bring the meteorological arrangements approximately up to the standard recommended

in the International Air Convention, the last one being reserved for consideration during financially more propitious times. Sanction was received with effect from 1st March 1933 for the facilities included under (1).

One principal item of readjustment was the re-allocation of surface observatories under the administrative control of the different forecasting centres. Before retrenchment the distribution stood as Headquarters 182, Calcutta 69, Karachi 30, Rangoon 24, while after re-allocation it became Headquarters 130, Calcutta 101, Karachi 74. On account of the increase in work of the Calcutta Office as a consequence of these adjustments, corresponding relief had to be given to that office by transferring all work in relation to the testing and supply of instruments to the Instruments Section of Headquarters. All schemes involving additional expenditure such as the resumption of intensive study of weather in northeast India in the nor'wester season, the expansion of the Poona workshop, the building schemes at Dum Dum and Karachi aerodromes and at the Agra Observatory and also the water supply and electric installation schemes at Kodaikanal Observatory had to be kept in abeyance. Owing to financial stringency the inspections of observatories and all other activities which involved travelling expenditure had to be reduced to the barest minimum. For the same reason, the department could not arrange for the broadcasting of synoptic data although neighbouring countries, such as Siam, Indo-China, the Federated Malay States and Ceylon, as well as Iraq, Turkey and Egypt started doing so. With the stoppage of the short-wave broadcasts of meteorological data from Karachi, foreign meteorological services made requests from time to time for special broadcasts, which could not be complied with except on a few occasions in the earlier months. Owing to the international importance of such broadcasts these would deserve first consideration when the financial situation improves.

In spite of the paramount need for strict economy and restriction of activities, demands, national and international, on the services of the department continued to increase. The French Air Mail changed their fortnightly service into a weekly one and made correspondingly increased demands on the resources of the department. The Imperial Airways made an alteration during the year in their London-Karachi air route and consequently certain changes had to be introduced in the meteorological organisation. Towards the end of the year it was learnt that the Imperial Airways would be operating a regular Passenger and Mail air service between London and Singapore and that the Tata Sons, Ltd., would be extending their air mail service up to Colombo. The possibility of these as well as of feeder services materialising early in the country pointed to an early need not only to revert to the pre-retrenchment conditions over North India but to bring the organisation in South India to a condition in which it could be serviceable to aviation. Co-operation of the department was sought in connection with the 1933 Everest flight and expedition. This was agreed to so far as the financial limitations would permit and necessary preparation made. A meteorologist from Headquarters was sent on deputation to help the Calcutta Meteorological Office in the issue of forecasts to these expeditions. The following

extracts from letters from Lord Clydesdale, the Chief Pilot and from Air Commodore P. F. M. Fellowes, leader of the Expedition, may be quoted.

Lord Clydesdale wrote—

"May I say that the success of the Expedition has in no small way been due to the care, trouble and efficiency of the Indian Meteorological authorities on our behalf. We are very grateful for the help and kindness rendered us."

Air Commodore Fellowes wrote—

"Before taking our departure I feel I must write and inform you how immensely valuable and accurate the information from your Department has proved to be. It is not going too far to say that without the services of your Department success could not have been secured.

The way in which we could always obtain information as to the strength of the wind at the height at which we were to operate, and the singular accuracy with which the amount of clouds has been forecasted, has been a unique experience."

The "Polar Year Commission" whose function was to organize extensive meteorological, magnetic, auroral and other geophysical observations during the second international polar year, August 1932 to August 1933, asked India along with all the other countries of the world to organize, on a definite plan, extensive and intensive observations of geophysical phenomena. One of the special objects of the project is to procure material for the preparation of synoptic weather charts for the whole of the northern hemisphere, a work which will be of immense scientific and practical value. Much as this department would have liked to co-operate actively in the Polar Year enterprise, especially as it is one of a world wide character and is an opportunity that arises only once in fifty years, it could not propose, in view of the present financial position in the country, to ask for any extra provision in its budget for the purpose. The department, however, tried to arrange, as far as could be done within the budget provision, for special ascents of sounding balloons and pilot balloons at existing upper air stations and for such special magnetic observations as were wanted at the Alibag Observatory. Much of the co-operation was rendered possible by the voluntary offer of honorary work on the part of a number of observers.

The year saw the inauguration of the scheme of Agricultural Meteorology, financed by the Imperial Council of Agricultural Research, though on a considerably reduced scale compared with that originally proposed. The scheme is to run on a restricted scale for three years and is to be in charge of a single Agricultural Meteorologist. The staff was recruited and the new Agricultural Meteorology Branch started work at the Meteorological Office, Poona, towards the end of August 1932.

The department had to consider in detail the modifications in meteorological organisation that would be necessary in the event of Burma separating from India. As neither Burma nor India could do without the meteorological data of the other country very close liaison between the meteorological services of the two countries would be necessary, so much so that one view is that it would be best for the meteorological service in Burma to be continued under the administrative control of the Director General of Observatories, even after separation.

While the department was settling down to the post-retrenchment conditions, its normal activities were continued as efficiently as possible. Warnings for cyclones, storms, depressions and squally weather and for heavy rainfall were issued as usual from Poona and Calcutta. The departmental forecasting centres at Karachi, Calcutta and Poona and the Royal Air Force centres at Quetta and Peshawar supplied weather reports and forecasts to aviators. Nearly 4,200 such reports were issued as against 3,300 during the previous year. The increase is perhaps significant as an index of the increase in aviation and its needs ; although, unfortunately, it coincided with the decrease in the number of forecasting centres. The department helped, as usual, the candidates for Pilots' B-license by arranging special lectures in Meteorology for their benefit and also for their examination in that subject. Special lectures were also arranged for the benefit of cadets of the I. M. M. T. S. " Dufferin ". Among the usual routine activities that were carried on during the year may be mentioned the seismological and magnetic observations at Bombay, solar observations at Kodaikanal, the time-service at Calcutta, the weather reports at different centres, compilation and tabulation of climatological data, exploration of upper air by routine pilot balloon ascents and periodical soundings with self-recording meteorographs.

While carrying on these normal activities, a fair amount of progress was also maintained in the research activities of the department. At Agra 91 sounding balloons were released and most of the instruments retrieved were found to have penetrated the stratosphere. Out of these soundings 20 carried instruments adjusted to reach only a height of three miles for special study of dust-storms. The Meteorological Reporter, Mysore, co-operated at the instance of the Agra Observatory in sending up special sounding balloons from Bangalore during thunderstorms. An improved type of wet and dry bulb meteorograph for measuring humidity in the Upper Air was evolved : improvements were made in the clown balloon meteorograph in order to adapt it for detailed records upto 1 km. as well as in the theodolite for following balloons at night. Certain investigations on thunderstorms in the Peninsula during the post-monsoon period and the characteristics of fronts during the south-west monsoon were completed. An experimental model of a modified pattern of Shaw-Dines' Micro-barograph with a photographic recording arrangement was made. At Bombay, a photographic electrograph was installed for the regular recording of atmospheric potential gradient as a routine measure. With the assistance of research students, investigations were in progress on problems such as discontinuous fluid motion, electrical charges of rain-drops, hydraulic seismographs, artificial vibrations of the ground, and disturbance of pressure at the bed of deep sea. At Calcutta an investigation on nor'westers based on results of previous years' intensive study and at Karachi a study of squalls were made. Heights of the base of low clouds were measured by means of " ceiling " balloons and search lights at Bombay, Poona and Agra and by the former method at various places on the air-route. At Quetta a study of the local rainfall was made, and at Peshawar investigations on the thermal structure inside cumulus clouds and on the dust content of air during

duststorms were undertaken. At Poona in the non-monsoon season and at Madras in the monsoon season 101 sounding balloons were sent up and investigation into upper air conditions in normal and disturbed weather were continued at Poona. Investigations on other subjects were also in progress partly with the help of research students. A study of the sizes of water drops in cloud and rain was made. Field work resulting in useful experience was done by a party of meteorologist and research students in camp at Khandala on the western edge of the Western Ghats throughout the monsoon in connection with a study of mists, fogs, clouds and precipitation. An examination of some Indian tephigrams from the point of view of latent instability was made. Statistical studies included the revision of some of the existing seasonal forecasting formulæ by the introduction of new factors and regrouping of Indian geographical divisions for the purpose of forecasting in a form more suitable to this purpose. In addition to several papers communicated to foreign journals, the department published three memoirs and six scientific notes written by members of the staff. Appendix B gives a list of the publications issued by the Department as well as of papers and contributions by the members of the staff to non-departmental journals, Indian and foreign.

Marine Meteorology—Storm Warnings.

The system of storm warnings for ports and shipping.—There has been no change in the system from that described in the last year's report. Warnings for the Bay of Bengal area were issued from the Calcutta Meteorological Office and those for the Arabian Sea area from the Poona Meteorological Office. The number of ports in the warning list was 38 on the west coast of India and 30 round the Bay of Bengal as against 37 and 28 respectively in the previous year. In addition to the sea ports, there were 8 river ports, 10 river police stations, 43 district police stations and 3 revenue sub-divisional officers on the Calcutta warning list. The latest weather information was supplied as usual to shipping at sea by means of weather bulletins issued regularly twice daily from the coastal radio stations and more frequently, sometimes as often as six times a day, when the weather situation demanded it. The total number of weather bulletins and warning messages issued during the year was over 13,500.

Services to ports around the Bay of Bengal.—Warnings were issued for 26 periods of disturbed or suspicious weather. Out of these, on 4 occasions the disturbances developed into storms of which the most interesting was the one that occurred between the 22nd and 25th May 1932 in the Bay of Bengal. With an advance of the southwest monsoon, conditions became unsettled in the southwest Bay of Bengal between the 15th and 20th May and concentrated into a cyclonic circulation between the Latitudes 10° and 18°N and Longitude 86° and 94°E on the 21st. The monsoon continued to advance northwards and by the 22nd morning it had spread over the whole Bay. Rough seas, rain-squalls and strong winds were reported from almost all the ships in the south

and central Bay. The unsettled conditions intensified in the course of that day and a depression had formed with centre near Latitude 17½°N and Longitude 86½°E on the 23rd morning and was then moving in a northerly direction. The depression rapidly intensified into a storm by the evening of the same day with its centre near Latitude 18½°N and Longitude 87°E with a core of winds of strong gale force as reported by S. S. "Chilka" and "Haresfield". The storm continued moving in a northerly direction and was rapidly approaching the south Bengal coast. Great danger warnings were issued to Burdwan and Presidency Divisions and danger warnings to 24-Parganas and Contai districts at 23 hrs. on the 23rd.

By the early morning of the 24th the storm had further developed and become one of severe intensity, and, moving in a northerly direction, lay in the neighbourhood of the Sandheads. The greatest departure of the barometric pressure recorded at the Sandheads was about 0·75 of an inch on the morning of the 24th. The telegraphic communication with Saugor Island was interrupted twice and Saugor Island hoisted Signal XI which indicates failure of communications.

Winds of whole gale and hurricane force (force 10 and 12) were reported by the 'F. L. V. S.', 'Star', 'Luna' and 'Fame' almost during the whole day on the 24th. On the morning of the 24th great danger warnings were issued to Dacca and Chittagong divisions in addition to Burdwan and Presidency divisions because of the tendency of the storm to move northeastwards.

After the morning of the 24th the cyclone took a northeasterly course and crossed coast near Saugor Island by midday. It continued to move in the same direction and passing about 50 miles east of Calcutta at about 14 hrs., it began to weaken and filled up in the course of the next two days.

The storm was responsible for widespread and locally heavy rain along and near its track (Orissa, Bengal and Assam) between the 22nd and 25th, some of the notable falls being 8″ at Saugor Island and 10″ at Pirojpur on the 23rd and 8″ at Akriganj, 10″ at Shillong and 18″ at Cherrapunji on the next day. It is reported that the heavy rain and strong winds associated with the storm caused widespread damage to property in south and east Bengal, particularly in the districts near the Meghna estuary. At Noakhali the river became furious and several houses and buildings were toppled down by the huge breakers dashing against the coast. Much damage to property was also reported from districts of Comilla, Dacca, Mymensingh and Khulna where several houses collapsed and boats capsized.

Thirty port officers sent in their remarks on the warnings issued to them during the year and almost all of them expressed satisfaction with the warnings received by them.

Services to Arabian Sea Ports.—Warnings for disturbed or squally weather were issued on 21 occasions; out of these, on 2 occasions the disturbances developed into storms of which the most important was the one that occurred between the 24th and 25th May 1932 in the Southeast

Arabian Sea. On the 24th morning pressure was observed to have undergone a rapid fall on the Malabar coast and the wind directions and force recorded at Amini Devi (NW—6) and by S. S. "Warora" off the coast near Lat. 11½°N and Long. 75½°E (S—8) and S. S. "Alipore" off Mangalore near Lat. 13°N and Long. 74½°E (SE—4) at 8 hrs. on the 24th indicated that a cyclonic circulation had set up and a depression formed with centre near Lat. 11°N and Long. 74½°E. During the course of that day, the depression seems to have intensified into a storm which was, later in the night, of severe intensity as indicated by the logs of S. S. "Jalaputra" at anchor at Calicut, of S. S. "Conte Rosso" bound for Bombay from Colombo and of S. S. "Celebes Maru" bound for Singapore from Bombay, the first and last of which experienced on the 24th-25th winds upto whole gale and hurricane force from a northerly to westerly direction. The observations indicate that the diameter of the inner hurricane region was roughly about 50 miles so that the storm was of small extent. The centre of the cyclonic storm appears to have passed inland south of Calicut between 9 and 11 P. M. on the 24th. The storm broke up rapidly thereafter; Calicut reported 11" of rain on the 24th. The station experienced such severe weather on the 25th morning that it was not possible for the observer to take the usual observations without undertaking serious risk. Strong gales continued to blow along and near the Malabar coast for almost the whole day on the 25th. Strong winds and rain caused considerable damage to railways and telegraph lines and to property in Calicut and its neighbourhood; newspapers reported about 16 deaths.

Seventeen port officers sent in their Annual Returns about the warnings sent to them; 16 of them said that the warnings were timely and satisfactory in every respect and that no change in the present system was necessary.

Exchange of information with ships at sea.—The chief sources of marine data are wireless weather messages from ships at sea and extracts from weather logs of ships calling at the principal ports on the Indian seaboard. The object of the system of radio messages from ships is to help in increasing the efficiency of cyclone warnings. The system which was started in 1914 was suspended during the War but resumed in 1921. Since that year there has been a steady increase in the use of this system by ships in the Indian waters. The following figures show the number of ships' messages from the Bay and the Arabian Sea during the year under report as well as in the previous years since 1921 :—

Year.	Ships' Messages.	Year.	Ships' Messages.
1921-22	649	1927-28	4,835
1922-23	656	1928-29	4,342
1923-24	2,237	1929-30	4,635
1924-25	3,633	1930-31	5,869
1925-26	3,689	1931-32	6,971
1926-27	4,282	1932-33	10,010

The figures show a most gratifying increase from year to year and a particularly large increase, indicating a larger amount of willing co-operation from the ships' Captains, during the year under review. It

is not possible to name here every steamship that sent messages, but those that sent more than 40 messages during the year are listed below along with the number of messages received from each :—

Name of Ship.	No. of Messages.	Name of Ship.	No. of Messages.
1. Angora	81	38. Hoogkerk	43
2. Arankola	60	39. Hawkins	63
3. Aronda	74	40. Investigator	63
4. Aungban	222	41. Jaladuta	72
5. Badarpur	257	42. Jalabala	76
6. Bahadur	72	43. Jalajyoti	47
7. Barjora	70	44. Jalapalaka	181
8. Begum	75	45. Jalatarang	103
9. Binfield	104	46. Jalavijaya	97
10. British Ambassador	42	47. Jalaveera	114
11. British Emperor	94	48. Jalarashmi	61
12. British Soldier	84	49. Karagola	50
13. British Sovereign	42	50. Karoa	69
14. Cathay	59	51. Khandala	71
15. Chakla	43	52. Kumsang	57
16. Chakrata	74	53. Maharaja	71
17. Chilka	149	54. Maloja	40
18. Chitral	42	55. Masimpur	143
19. City of Sydney	43	56. Margha	53
20. Cocanada	86	57. Mongolia	51
21. Corfu	114	58. Morvada	44
22. Cranfield	89	59. Nuddea	56
23. Cumberland Warship	39	60. Ormonde	41
24. Dogra	77	61. Rajula	139
25. Edavana	86	62. Ranpura	47
26. Egra	42	63. Rohna	124
27. Ellenga	85	64. Singu	162
28. Ellora	65	65. Sirsa	63
29. Erinpura	141	66. Tairea	76
30. Ethiopia	149	67. Takada	50
31. Gamaria	43	68. Tilawa	61
32. Gazana	42	69. Tuscania	49
33. Haresfield	62	70. Victoria	41
34. Hatipara	46	71. Warialda	51
35. Havildar	62	72. Warora	93
36. Homefield	85	73. Winkfield	66
37. Hosang	96	74. Yuensang	43

The second principal source of marine data for purposes of study is the log extracts collected by clerks in Calcutta and Bombay and the other agencies mentioned below. The British India Steam Navigation Company, the Scindia Steam Navigation Company, the Burma Oil Company, Limited, Rangoon, and the Asiatic Steam Navigation Company have standing arrangements with certain of their ships' Captains to

copy and despatch extracts from weather logs in two kinds of forms, which are supplied to them for use during ordinary weather and during disturbed weather respectively. The Port authorities at Rangoon also continued to render help by allowing the observers of the Time Ball and Tidal Observatory of the Port Commissioners to collect ships' data. Occasionally, in special cases of interesting disturbed weather, logs of steamers were collected through the help of the Colombo Port authorities. A total of over 4,000 logs was recorded during the year.

Inland Weather Warnings and Forecasts.

The majority of officers to whom warnings of heavy rain on land are issued from Poona and Calcutta were district officers and officers of the Irrigation, Railway and other departments. The number of officers on the warning list was 312 including 25 officers of the Telegraph Department who generally require warnings for strong winds. The number of officers in Bengal on the list of great danger warnings was 461 including 43 district police stations. In addition to these specific warnings to individual officers the Daily Weather Telegraphic Summary contains heavy rainfall forecasts and its subscribers thus automatically get the warnings. The forecasts and warning messages issued from forecasting centres during the year numbered 5,908 while 618 telegrams of heavy rainfall reports were sent direct to various officers by local meteorological observers. Reports on the working of the system were received from 82 officers almost all of whom expressed satisfaction with the warnings issued. The following remarks may be mentioned :—

The Chief Officer, Ahmedabad Municipality—

"From the figures of rainfall given in statement 1, it will appear that most of the warnings have more or less been followed by the actual occurrence of the event as predicted. Warnings received on 15th July 1932, 25th July 1932 and 8th August 1932 were most accurate as there was heavy rainfall in Ahmedabad on these days."

The Executive Engineer, Upper Division, Agra Canal—

"I have the honour to state that during the rains in 1932 two flood warnings were received, one on the 17th August and another on the 24th of September. The first warning was followed by a small flood which rose to a maximum of 42,000 cusecs on the morning of the 20th. The second flood warning gave notice of a flood which reached a peak of just about 80,000 cusecs on the 28th of September. Both warnings were thus very useful."

The Executive Engineer, Karnal Division, Western Jumna Canal—

"A flood on 9th September 1932 when Ponta recorded 33·00 ft. was the highest since the record flood of 1924 when Ponta gauge read 43 ft. The warning of this flood had already been received and the forecast amply fulfilled. * * * * The warnings serve a distinctly useful end and therefore should be continued."

Postmaster-General, Burma—

"The warnings were timely, useful and satisfactory in every respect."

The Divisional Engineer, Telegraphs, Calcutta Division—

Storm warnings and depression reports sent by you were very helpful. The warnings were timely, useful and satisfactory in every respect and I thank you for the help received by this Division."

Aviation forecasts.—The responsibility for the main trans-India air-route continued divided between the meteorological offices at Karachi and Calcutta. The Quetta and Peshawar officers, as usual, took part in the supply of forecasts to the Royal Air Force planes. Besides the regular air services, aviation forecasts were supplied on requisition to various stray fliers, members of the Indian Flying Clubs, and Royal Air Force Flying Squadrons. Considerable increase took place in the demands of aviation on this department inasmuch as the French air mail service became, during the year, weekly instead of fortnightly and the Imperial Airways changed their London-Karachi route to the southern side of the Persian Gulf. A new airmail service between Karachi and Madras was inaugurated by the Tata Sons, Ltd., and the Poona Office was called upon to give them meteorological advice. The meteorolcgical organisation in South India and the equipment of the Poona Office for the issue of aviation forecasts have not yet been developed to enable satisfactory meteorological advice to be furnished to a regular air-services. In spite of these handicaps, the forecasting centres did the best that they could do under the circumstances and it was encouraging for them to receive appreciatory messages from various sources, among which may be quoted the following :—

The Assistant Manager, Java-Bengal line, Calcutta, wrote—

"We have been asked by Hondong, first pilot of the 'Ph-Aip' which arrived yesterday to return to you the enclosed weather forecast and to inform you that the weather conditions have been identical with those mentioned in your forecast."

The Calcutta Representative of the Royal Dutch Air Lines wrote—

"We should like to express our appreciation of your assistance in connection with the forecasts supplied to our pilots and also the accuracy of the same. Needless to mention the information given by you is of paramount importance specially during the monsoon."

During the course of a paper on "The Amsterdam-Batavia Weekly Service" presented before the Royal Aeronautical Society, London, on 2nd February 1933, Mr. A. Plesman, Managing Director of the Royal Dutch Air Lines (K. L. M.) said—

"..... the K. L. M. has great admiration for what, with extremely scanty means, has already been accomplished in that country (India) and for the very active interest shown in aeronautics by British Indian Meteorologists."

The total number of aviation forecasts issued was about 4,199, of which Karachi was responsible for 3,091, Calcutta for 621, Poona for 138, Quetta for 172 and Peshawar for 177.

Use was made of the chain of wireless stations along the Trans-India route for the transmission of weather reports and forecasts to aircraft, as such messages on behalf of aviation were handled free, so far as the Meteorological Department is concerned.

Offices and Observatories.

A list of the staff of the India Meteorological Department as it stood on the last day of the year under review is given in Appendix 'A'. The 3rd edition of the "Note on Functions and Organisation of the India Meteorological Department", the issue of which was held up last year, was prepared and sent to the Department of Industries and Labour for publication early in 1933. On account of financial stringency, the annual Conference of departmental officers was not held even during 1932. For the same reason, no officers except Dr. A. L. Narayan, who was elected President of the section of Physics and Mathematics, were deputed to attend on duty the Patna meeting of the Indian Science Congress in January 1933.

Dr. K. R. Ramanathan was elected a member of the Radiation Commission of the International Meteorological Organisation and Dr. L. A. Ramdas, Agricultural Meteorologist, of the International Commission on Agricultural Meteorology.

Headquarters Office, Poona.—A brief review of the scientific work done in this office has already been mentioned amongst the Chief Features at the beginning of this Report. A helpful means of maintaining interest on the scientific side is the colloquium of which 16 meetings were held, the discussion at each meeting being opened by a member of the staff or one of the research students who took as his subject either his own original work or a recent important paper published in a foreign journal. On the administrative side, the attention of the office as a whole was directed to adjustments to the post-retrenchment conditions. The general work of the office is best described by reviewing briefly the activities of the different Sections separately.

(*a*) *General Section.*—This Section is responsible for the administration of headquarters and sub-offices and deals with budget, accounts, establishments, general registry and technical questions involving change of policy or fresh expenditure as well as arrangements for the co-ordination of the technical work of the department. A scheme for the transmission of current weather information along the air-routes for the benefit of pilots was introduced during the year and an extension of the scheme by including immediate reports of adverse weather and improvement thereof was considered. A scheme of meteorological facilities for the Karachi-Bombay-Madras air-mail service started by the Tata Sons, Ltd., was worked out and submitted to Government. Sanction was received during the year for the inauguration of a new branch of Agricultural Meteorology which was being held up for some time past for financial reasons. Proposals were submitted to Government in regard to the revision of the scales of pay of subordinate posts in the department. The post-retrenchment adjustments involved considerable work in this section. In the scheme of retrenchment in the Meteorological Department, it was proposed that the expenditure incurred by the department exclusively for the Royal Air Force in providing meteorological

facilities for that Force should be recovered from Army estimates in order that the expenditure of the Meteorological Department may be brought down. The Government of India decided during the year that this need not be done.

(*b*) *Weather Section.*—The functions of this Section have been partly outlined in previous pages dealing with storm and heavy rain warnings. The Section is responsible for the issue of weather telegrams, the daily, weekly and monthly weather reports and for the preparation of portions in the Annual Summary of the India Weather Review relating to weather. During the year, the additional responsibility of issuing aviation forecasts on the Ahmedabad-Madras section of the newly started Karachi-Madras weekly air-mail service was undertaken by the Section. The need for a second afternoon chart thus became very keen and proposals for its preparation were submitted, *inter alia*, to Government in connection with the Karachi-Madras air service scheme. Sanction for the provision of this chart was not received and the Section has had therefore to work under unsatisfactory conditions so far as aviation forecasts in South India are concerned. Arrangements were made for displaying visual signals on the roof of the Poona Meteorological Office to notify to the passing air-mail on its flight from Bellary to Bombay the cloud heights at the latter place. Arrangements were also made for the introduction of a scheme of Current Weather reports for the Tata Air Mail during the monsoon season.

Climatological information in respect of various air routes under contemplation was supplied during the year to the Royal Air Force as well as to the Director of Civil Aviation. Proposals for exchange of meteorological broadcasts between India and the neighbouring countries like Siam and the Federated Malay States were submitted to Government and, with the co-operation of the Director of Wireless and the French Consul General at Calcutta, arrangements were made for trial exchange of broadcasts between Calcutta and Hanoi, and Calcutta and Singapore.

Arrangements were made for getting ships' telegrams direct from the Colombo radio instead of through the Colombo Observatory during certain periods.

(*c*) *Observatories Section.*—This Section administered and arranged for the inspection of departmental observatories not under charge of sub-offices. Re-arrangements of control of observatories consequent upon the abolition of the Delhi and Rangoon offices and the extension of the spheres of the Karachi and Calcutta offices were completed during the year. As a result, the Headquarters office is now in direct charge only of observatories in Kashmir, Gujarat, Central India, Central Provinces and the Peninsula. Inspection of observatories continued restricted on account of financial reasons, only 26 observatories being inspected. One second class non-reporting observatory, one second class reporting observatory and one third class non-departmental observatory were started and one fifth class observatory and one fourth class non-departmental observatory closed during the year. Arrangements were made

to record as many as possible of the special observations required by the International Commission at the Reseau Mondial stations. The compilation of a revised Handbook of Observatories was completed. The 'E' Registers and note-books of observations at all non-reporting stations were replaced by Monthly Meteorological Registers and Pocket Registers. A selected number of fifth class observatories were instructed to telegraph rainfall and non-instrumental observations in the Brief Weather Code.

(*d*) *Instruments Section.*—The Section continued to be responsible for the purchase, test, standardisation and repairs of meteorological instruments and their issue to all surface observatories of the department as also for the supply of forms and stationery to them. For the efficient and rapid handling of a large number of instruments requiring test and comparison, special apparatus and equipment such as test-chambers for barographs, thermographs and hygrographs, constant temperature baths for thermometers, etc., were designed and constructed. The high level stations Kodaikanal, Srinagar and Quetta which were selected for collection of data during the international Polar Year were supplied with up-to-date instruments in place of the old ones and arrangements were made to provide them with suitable forms for tabulations. Instructions were also issued to them for additional observations to be made at some of the synoptic hours. Arrangements were made at Poona to take additional observations on electrical conductivity of the air and potential gradient of the earth's electrical field on international days of all the three orders. The re-modelling of old anemometers and manufacture of windvanes according to departmental specifications proceeded as usual. The stock of issuable barometers for use as inspection standards at auxiliary centres was replenished. Arrangements were made for the direct comparison of standard barometers at Agra, Bombay and Poona with the departmental standard at Calcutta. During the year under review 350 instruments were issued to departmental observatories, 58 instruments were loaned, 734 instruments tested and 267 instruments repaired. The Section co-operated with the new branch of Agricultural Meteorology by loaning a complete set of meteorological instruments and equipment for the agricultural observatory. The Section continued considerably handicapped during the year in regard to workshop staff.

(*e*) *Marine Section.*—The usual duties of the Section were carried out satisfactorily. These consisted of co-ordinating the work of collection, examination and study of ships' weather logs and of maintaining contact with the shipping interests in Bombay. The Section co-operated as in previous years with the authorities of the I. M. M. T. S. "Dufferin" in the meteorological training of the cadets and helped by lectures on meteorological subjects by examining essays of candidates and preparing a set of weather chart exercises for them. Through the courtesy of the Principal Officer, Mercantile Marine Department, Bombay, a meeting of ships' captains was arranged in order to elicit their opinions regarding the form of code they considered most suitable for the transmission of

weather messages. Arrangements were made with the Director, Royal Indian Marine, for the reception of wireless weather messages from ships belonging to that body. The Section undertook to compile Indian Ocean Weather data for the preparation of weather charts for the Polar Year, 1st August 1932 to 31st August 1933, at the request of the International Meteorological Secretariat. Two charts of typical Arabian Sea storms were prepared and sent to the Principal Officer, Mercantile Marine Department, Bombay, at his request.

(*f*) *Upper Air Section.*—Sounding balloon work was carried on regularly at Poona except during the monsoon season, in which period regular ascents were made only at Madras. During the year 101 meteorographs were let off, of which 63 have been recovered. Observations of upper air temperatures and humidities continued to be made from aeroplanes by the Royal Air Force at Peshawar, Quetta and Karachi and the data were worked out at Poona in a form suitable for publication and included in the monthly publication of "Upper Air Data". The pamphlet on meteorological organisation for the supply of weather information to aviators was distributed to various aviation interests. Reprints of the code portion of the pamphlet were also made to meet demands from interested public. In order to obtain an idea of the heights at which low clouds occur during the monsoon season, regular ceiling balloon ascents were made during the months July to October. In connection with the Karachi-Madras air-mail service, the Director of Civil Aviation was supplied with monthly normal percentage frequencies of visibility for Bombay and Poona for the months May to September. The study of upper air conditions in normal and disturbed weather was continued.

(*g*) *Library Section.*—The duties of the Section comprise the care of the library, the editing and distribution of departmental publications, the supply of climatological and general meteorological information in reply to enquiries and the issue of the seasonal rainfall forecasts as well as statistical studies relating to them.

The number of books, pamphlets and periodicals either purchased or received in exchange for the publications of the department or as complimentary copies was 776. Three Memoirs and 6 Scientific Notes were published during the year and the routine publications issued as usual. The number of addresses on the free distribution list of departmental publications was 346 at the end of the year. About 400 enquiries for climatological and meteorological information were answered. The usual seasonal forecasts were issued. Statistical work included the revision of some of the forecasting formulæ by the introduction of new factors. The re-grouping of the geographical divisions of India for forecasting purposes was being considered.

The climatological branch of the section, as usual, scrutinised the accuracy of the records of surface meteorological data, prepared meteorological tables for the routine publications of the department and supplied periodical reports and data to various Government and public

bodies. The advisory functions of the Director General of Observatories with regard to the registration of rainfall, inspection of raingauges and publication of the provincial rainfall tables were also carried out by this branch.

Arrangements were made for the scrutiny of afternoon data from 2nd class observatories and for their publication in the Monthly Weather Report from January 1933. It was also arranged to publish the 4 and 14 hrs. G. M. T. data of the Persian and Baluchistan stations and of the 3rd and 4th class non-reporting observatories, in the Monthly Weather Report from January 1933 onwards. Mean frequencies of minimum temperature from April to October for the period 1901 to 1925 were calculated and supplied to the President, International Commission for Agriculture, Stockholm. Normals of different elements were prepared for 30 stations by utilising the data upto 1930.

(*h*) *Agricultural Meteorology Branch.*—The work of this new Branch can be classed under two heads : (*a*) statistical and (*b*) experimental. The programme of statistical investigation is to begin with a critical enquiry into the available data on the area sown and yield per acre of crops for the various presidencies and districts in India and proceed, after careful selection, to correlate some of them with the accumulated meteorological data. Accordingly the Agricultural Meteorologist got into touch with the provincial agricultural departments and began to collect the available Season and Crop Reports and the data of some of the experimental farms. A beginning was made in the subject of correlation of the yield and acreage figures of the Bombay Presidency with special reference to the Cotton crop. To discuss the various problems of agriculture in relation to weather the Agricultural Meteorologist met the various officials of the Department of Agriculture, Bihar and Orissa assembled at Patna during the Science Congress week in January 1933, and later visited the Imperial Institute of Agricultural Research, Pusa, the office of the Director General of Commercial Intelligence, Calcutta, the Agricultural College at Cawnpore and a few other places.

Suggestions regarding the equipment for an Agricultural Meteorological Observatory, the method of taking observations and other technical advice were given by correspondence, on request, to about 20 Agricultural Research Institutions or workers.

In order to help agricultural workers who may wish to get training in Agricultural Meteorological observations, and to standardise the instrumental equipment and the methods of observations suited to agricultural needs, a model observatory was started in the farm of the local Agricultural College, and arrangements were made to study the variations of climate inside different crops. Arrangements were being made for starting regular observations of temperature and moisture in the air and in the soil, evaporation from water and soil, percolation of

water through the soil, radiation from the sun and the sky and for studying the meteorology of the air layers near the ground. Some instruments for the measurement of air, soil, and plant temperatures and evaporation of water were got made locally, and these were under test. The Branch would seek the co-operation of various Agricultural Departments in order to arrange for detailed meteorological observations to be collected side by side with crop observations in at least a few important centres.

Upper Air Observatory, Agra.—This observatory administers all the pilot balloon stations of the department except those at other regional centres such as Karachi, Calcutta or Poona where the staff are under the charge of local officers. Four pilot balloon stations were opened during the year and five inspected. The Government of Mysore sanctioned the necessary staff for making a second regular balloon ascent daily at the pilot balloon observatory in Bangalore. Necessary equipment began to be supplied from Agra. In order to co-operate with the Houston Mount Everest flight and the Ruttledge Everest Expedition, the pilot balloon stations at Patna and Dacca were shifted temporarily to Purnea and Darjiling respectively. For the manufacture of hydrogen on a scale sufficient to meet the increasing demands thereon, an additional electrolyser, a transformer, 3 motor generators and 2 compressor motors were installed, and run by power obtained from the local Electric Supply Company. The output of hydrogen during the year was 2,31,000 cubic feet as against 1,84,000 cubic feet during the previous year. During the year the Agra Observatory became a centre for the training and examination of candidates for the pilots' 'B' license. 91 sounding balloons were let off during the year and 51 retrieved, 6 of which had been let off during the previous year. Mention of other investigational activities of the observatory has been made under the Chief Features. The duties of a 1st class observatory and seismological station were carried on as usual, and special cloud observations were arranged in connection with the International Polar Year scheme.

Colaba and Alibag Observatories.—The routine meteorological, seismological, magnetic and time work at Colaba and Alibag Observatories was carried on as in previous years. The Colaba Observatory is the departmental centre for the seismological studies. As usual, the Observatory carried out time service for the Port of Bombay efficiently and also looked after a large number of chronometers and watches belonging to the R. I. M. and R. N. The Observatory volumes for 1929 and 1930 were issued and that for 1931 was got ready. Records from the photographic electrograph began to be obtained as a routine measure. Details of seismograms and photograms were sent on 7 occasions to foreign institutions. 19 seismic telegrams in the International Code were sent to London for issue by broadcast. In connection with the needs of the Karachi-Bombay-Madras air mail service, ceiling balloon ascents were made for determining the height of low clouds during the monsoon months. These heights were also measured by means of a searchlight during nights. The Observatory co-operated with the Military

authorities by supplying upper air and meteorological information on 30 occasions for artillery practice.

The Colaba Observatory continued to issue a Weather Summary the material for which is telephoned from Poona. The Summary covers the principal features of the daily weather over Western India and its issue is limited to May to November inclusive. It also contained a biweekly rainfall and crop report for Western India.

The Observatories collaborated, as far as was practicable, in the scheme of observations under meteorology, terrestrial magnetism and atmospheric electricity in connection with the International Polar Year. Two Eschenhagen variometers were arranged to give quick-run records of horizontal and vertical components of the earth's magnetic field from August and September 1932, respectively. The research activities of the Observatory have been mentioned under the " Chief Features ".

Alipore Observatory and Meteorological Office, Calcutta.—The principal functions of storm warnings, heavy rainfall warnings for the Bay of Bengal and the surrounding areas and the issuing of forecasts to aviators including the regular air mail services on the route between Allahabad and Victoria Point were carried on as satisfactorily as was possible under the limitations laid down by post-retrenchment conditions. The meteorological, seismological, time-determination and time-signalling duties of the observatory were carried on satisfactorily. Temperature, pressure, and inversion indicators designed by Dr. Das of the Alipore Office were sent up regularly with pilot balloons. Special sets of observations were taken for the International Meteorological Commission. The Calcutta Daily Weather Report was issued as usual throughout the year. As a result of post-retrenchment adjustments, the administrative control of all observatories in the east United Provinces was added to the duties of the Calcutta Office. Five 5th class observatories were raised to second class status, one second class observatory was started and 42 observatories inspected during the year. The Brief Weather Code was introduced at nine observatories. Arrangements were made with the Indian State Broadcasting Service fo broadcasting nor'wester warnings. Copies of storm warnings sent to the Madras area were supplied to the Secretary to the Government of Madras from 3rd August 1932. Special forecasts and weather reports were supplied on request on various occasions, as for example, to the Engineer-in-Chief, Bally Bridge Construction, and the Bridge Foreman, Chandmari Overbridge, Howrah. Special Weather Bulletins for oceancraft were issued to the Indian Broadcasting Company whenever there was any disturbance in the North Bay.

Trial broadcasts and India Weather Bulletins were issued from Calcutta for reception by Hanoi between the 1st and 15th March 1933. The reception at Hanoi was reported to be a failure whereas the broadcasts from Hanoi were fairly well received at Calcutta. A second trial exchange of broadcasts was therefore arranged for. The Malayan Meteorological Service at Singapore was also requested to listen in to the trial broadcasts from Calcutta.

The work of compiling 12 hrs. G. M. T. land and sea observations in connection with the preparation of weather maps of the northern hemisphere undertaken by the Polar Year Commission was taken up in respect of the area under the control of the Calcutta Office. Arrangements were made for the supply of weather information and forecasts to the Mount Everest Flight and Expedition. A meteorologist from Poona was sent on deputation to help the office in this extra work.

Meteorological Office, Karachi.—The office continued to furnish the aviation forecasts on the main air-route extending from Bushire on the west to Allahabad on the east. Route forecasts to Royal Air Force flights over Karachi-Jodhpur-Delhi and other routes were also supplied whenever required. Responsibility in respect of regular aviation forecasts between Karachi and Ahmedabad to the newly started Karachi-Madras Air-Mail Service was added during the year to the functions of the office. Other changes that increased its aviation responsibilities have been mentioned under the 'Chief Features' and under 'Aviation Forecasts'. On the administrative side, the control of observatories in east Rajputana, west United Provinces, the Punjab, Baluchistan and the North-West Frontier Province was transferred to the Karachi Office as a post-retrenchment measure. The office continued to function as one of the main supply centres for synoptic and other observational data to the Royal Air Force forecasting centres at Quetta and Peshawar, and to the meteorological station at Hinaidi through the Royal Air Force W/T station at Drigh Road. The arrangement made in the previous year for the Meteorologist at Hinaidi to get copies of observational data from this Department's stations in Persian Gulf and Mekran continued and further arrangements were made for morning and evening upper wind data from Bahrein and Muscat to be similarly made available to the local wireless stations for transmission. The Aircraft Depot, Drigh Road, continued their valuable assistance in supplying observational data from aeroplane ascents, the number of such ascents being 147 during the year. The total number of synoptic weather reports, upper air observations and forecasts forwarded to the Royal Air Force at Drigh Road was 3,953. As usual, meteorological information was supplied to the public including officials of the Agricultural Department, to the Karachi Port, newspapers, engineers, municipality, railways and so on while a number of warnings was also issued to various bodies. The Karachi Daily Weather Report started from 11th February 1932 continued to be published and favourably received by the public.

Arrangements were made for special observations in connection with the International Polar Year work. 12 hrs. G. M. T. land and sea observations were also compiled for the weather map of the northern hemisphere in the same connection. Co-operation was extended to Prof. Mehta of the Agra College in connection with his work on cereal rusts which he is carrying on under the auspices of the Imperial Council of Agricultural Research. Slides were exposed for him on an aëroscope supplied by him at a height of 156 feet on the mast at the Drigh Road Observatory.

Only 14 observatories could be inspected during the year. Pending the starting of a full fledged pilot balloon and surface observatory at Sherjah on the new Imperial Airways' route from London to Karachi, a non-instrumental observatory was started there with the co-operation of the Imperial Airways. Assistance was given for the starting of observatories at the Agricultural Farms at Dadu, Oderlal and Pad-Idan in Sind. An extended weather chart comprising the region from Burma to Jask was brought into use from October 1932.

The office continued in the hired building in the Civil Lines at Karachi as the building schemes could not make headway owing to financial stringency.

Kodaikanal Observatory.—The solar and astronomical researches during the calendar year 1932 have been summarised in the Annual Report of the Kodaikanal Observatory. The routine work of the observatory as mentioned in previous reports was continued satisfactorily. Seven staff meetings were held during the year for the discussion of scientific topics or papers. The schemes relating to supply of water and electricity to the observatory and quarters could not be taken up to Government for financial reasons. The Reifler Clock from Madras was mounted and regulated. A new Milne-Shaw seismograph was brought into use.

Meteorological Office, Quetta.—This office continued under the charge of the temporary member of the Indian Meteorological Service who replaced the Royal Air Force Meteorological Officer in 1930. Detailed local forecasts and warnings as well as a daily weather report for the area Baluchistan, Sind and the Punjab continued to be issued as usual during the year. In addition to these, 221 special route forecasts and weather reports were issued. Among other routine duties of the office were the conducting of the first-class observatory work and the collection of meteorological observations taken regularly by pilots in the Royal Air Force flying machines in that area. The observatory took special cloud and other meteorological observations in connection with the International Polar Year.

Meteorological Office, Peshawar.—This office is in charge of the Royal Air Force Meteorological Officer, who is only technically under the control of the Director-General of Observatories. His functions are the supply of weather reports to the Royal Air Force comprising detailed local forecasts and warnings against heavy rainfall, etc., for the immediate neighbourhood of Peshawar and the issue of route forecasts and special forecasts for Royal Air Force and other military units. 221 such forecasts were issued. This centre also undertakes duties of a first class observatory and pilot balloon station, and the collection of upper air temperature observations through the agency of Royal Air Force aeroplanes as well as giving replies to all local enquiries.

Other Observatories.—The numbers of observatories of various classes are shown in the table below, which also gives the corresponding figures at the end of the previous year. For a description of classification of these observatories, the reader is referred to Appendix " C ".

	On 31st March 1933.	On 31st March 1932.
I Class	15	12
II Class	163	160
III Class	86	82
IV Class	22	23
V Class	24	25
Non-instrumental	7	*Nil*
Total*	317	302
Non-departmental	61	59

The records of the non-departmental observatories were scrutinised by this department and in most cases utilised in the daily weather reports and other departmental publications. The importance of these observatories need hardly be emphasised and the co-operation of the Indian States and other public bodies, who maintained them for the furtherance of the study of Indian meteorology, is much appreciated. Among these may be mentioned the Kingdom of Nepal and the States of Hyderabad, Kashmir, Mysore, Travancore, Baroda, Jaipur, Bhopal, Mira', Ichalkaranji, Patiala, Bikaner, Bahawalpur, Jhalawar, Cooch Behar and Nawanagar, the municipalities of Murree, Ahmedabad, Mussooree and Coonoor and the Agricultural Departments of the Punjab and Bombay.

Rainfall Registration.

The rainfall data collected by the provincial rainfall organisations, for which the Director General of Observatories is the consulting authority, are published in the provincial rainfall tables, which are collected and issued in a single volume for the whole of India by this department. The number of stations included in the organisation in the different provinces and the number inspected during the year, together with corresponding figures for the previous year, are given in the following table. On the whole the work of rainfall registration was carried out satisfactorily throughout India.

* This total includes the non-departmental observatories whose number is shown separately in the next row.

Rainfall Registration during 1932-33.

No.	Province	No. of raingauges at the end of			No. of raingauges inspected.			Remarks regarding the condition of raingauges.
		1932-33.	1931-32.	Change.	1932-33.	1931-32.	Change.	
1	Burma . . .	215	218	—3	211	207*	+4	Satisfactory.
2	Assam . . .	128	128	0	109	121	—12	Satisfactory.
3	Bengal . . .	235	235	0	194	203	—9	Satisfactory.
4	Bihar and Orissa .	305	301	+4	254	245	+9	Satisfactory.
5	United Provinces .	269	269*	0	259	221	+38	Satisfactory.
6	Punjab . . .	195	195	0	157	167	—10	Satisfactory.
7	Jammu and Kashmir	31*	31	0	10	7	+3	Satisfactory.
8	North-West Frontier Province.	30*	30	0	25	27	—2	Satisfactory.
9	Baluchistan . .	72	73	—1	51	66	—15	Satisfactory.
10	Bombay . . .	306	307	—1	251	259	—8	Satisfactory.
10(*a*)	W. India States .	27	27	0	0	0	0	Satisfactory.
10(*b*)	Baroda . . .	13	13	0	6	5	+1	Satisfactory.
11	Rajputana . .	183	182	+1	164	171	—7	Satisfactory.
12	Central India . .	121	120	+1	98	92	+6	Satisfactory.
13	Central Provinces .	188	190	—2	167	144†	+23	Satisfactory.
13(*a*)	Berar . . .	42	42	0	42	38	+4	Satisfactory.
14	Hyderabad . .	53	47*	+6	2	2	0	Satisfactory.
15	Mysore . . .	74	75	—1	74	75*	—1	Satisfactory.
16	Coorg . . .	9	9	0	7	9	—2	Satisfactory.
17	Madras . . .	512	513	—1	485	495	—10	Satisfactory.

NOTE—

* Meteorological observatories were included upto last year.

† Number of inspections of raingauges under the Irrigation Department and in the Feudatory States was not included upto last year.

Heavy Rainfall Reports.—Heavy rainfall is often so very local that small unrepresented areas can have as much as 10 inches without the weather chart, with the present net work of daily reporting stations, conveying the least suggestion of the local deluge. To obtain reports of such local heavy rain promptly for the Daily Weather Report, it was arranged 12 years ago that observers at the provincial raingauge stations should telegraph to forecasting centres falls of 5 inches or more. The number of such telegrams received during 1932-33 was 279 as compared with 257 in the previous year.

Snowfall Registration.—Information about the distribution and the time of occurrence of snowfall in the Himalayas and the Afghan mountain areas was on the whole tolerably complete and the thanks of the department are due to the various officers who collected and forwarded the reports.

Concluding Remarks.

The Meteorological Department owes a large part of its usefulness to the sympathetic assistance it receives from other departments. Officers of various Government departments help the meteorological work as Honorary Superintendents of Observatories or in other capacities. The Posts and Telegraphs Department assist this department in the rapid transmission of meteorological information particularly in connection with the warning services.

Weekly telegrams are received from April to October from the Director, Royal Alfred Observatory, Mauritius. These telegrams give valuable information of the weather conditions in the Indian Ocean, and the department is indebted to this observatory for the punctual transmission of the information.

The department is greatly indebted for important information on meteorological conditions prevailing before and during the southwest monsoon to the Controller, Physical Department, Cairo ; the Directors of the Observatories at Buenos Ayres, Santiago ; the Astronomer, Royal, Cape Town ; Director L'Observatoire Physique Central, Leningrad ; the Secretary, Friends' Industrial Mission, Banani Pemba, Zanzibar ; the Principal Medical Officer, Tanganyika Territory, Dar-es-Salaam ; the Commonwealth Meteorologist, Melbourne ; Director of Agriculture, Salisbury, Rhodesia ; Chief of the Weather Bureau, Washington. Thanks are due to the Director, Koninklijk Magnetisch und Meteorologisch Observatorium, Batavia, for similar information and also for the daily weather telegrams from Sabang in Sumatra during the cyclone months April, May and October to December.

Thanks are due to the Marine Superintendents of the British India Steam Navigation Company, the Scindia Steam Navigation Company, the Asiatic Steam Navigation Company, and the Burma Oil Company for continuing the arrangement under which many captains of their fleets send weather logs to this Department. The Principal Officer, Mercantile Marine Department, Bombay, the Deputy Conservator of the Port of Bombay, the Deputy Conservator of the Port of Calcutta, and the Flag Officer Commanding and Director, Royal Indian Marine, have been willing helpers of this department, for which it is grateful to them.

The department is indebted to the Government of His Exalted Highness the Nizam of Hyderabad and to the Government of His Highness the Maharaja of Mysore for their co-operation by regular collection of pilot balloon data at the Nizamiah Observatory, Begumpet (Hyderabad) and the Central Observatory, Bangalore respectively, as also for their assistance in the recovery of sounding balloon instruments found in their territories. The Department is also grateful to the Government of Travancore for their co-operation by regular collection of pilot balloon data at Trivandrum.

The department thanks the Directors of Agricultural Departments and Institutions in the different provinces and the various agricultural research workers in the country for their valuable co-operation with the new Branch of Agricultural Meteorology. It is also indebted to the Director of Agriculture, Bombay Presidency, and the Principal of the Agricultural College, Poona, for kindly providing the space and facilities for that branch to conduct the experimental work.

Thanks are due to the Eastern Telegraph Company for charging this Department half the usual rates for the transmission of South American Weather telegrams. Thanks are also due to the various pilots of the Imperial Airways, Limited, Tata Sons, Ltd., and the Karachi-Delhi Air Service and to the Dutch and French Air Services for the supply of weather logs to this department ; to the various ships' officers, who send their marine weather logs direct to this Department ; to the Superintendent of the Colombo Observatory for the most useful help he has rendered from time to time in connection with storm warning work and for the useful data of Ceylon stations supplied to this Department.

POONA ;
The 31st August 1933.

S. K. BANERJI,
Offg. Director-General of Observatories.

APPENDIX A.

THE STAFF OF THE INDIA METEOROLOGICAL DEPARTMENT AS IT STOOD ON 31ST MARCH 1933.

METEOROLOGICAL OFFICE, POONA.

Director-General of Observatories.

C. W. B. Normand, M.A., D.Sc. (Edin.) (on leave ex-India).

S. K. Banerji, M.Sc., D.Sc. (Cal.) (*offg.*).

General Section.

Meteorologist	V. V. Sohoni, B.A. (Hons.), M.Sc. (Bombay).
Assistant Meteorologist	B. N. Sreenivasaiah, M.Sc. (Cal.).
Superintendent	C. P. Venkataramier, M.A. (Madras).
Assistants	6.
Stenographers	4.
Cashier	1.
Clerks & typists	11.

Weather Section.

Meteorologist	S. Basu, M.Sc. (Allahabad).
Assistant Meteorologist	B. N. Desai, M.Sc. (Bombay), Ph.D. (Edin.), B.A., LL.B. (Bombay).
Assistants	2.
Clerks & Tabulators	12.
Draftsmen	5.

Observatories Section.

Assistant Meteorologist	Barkat Ali, B.A., M.Sc. (Punjab).
Assistant	1.
Inspector of Observatories	1.
Clerks	3.
Junior Observers	8.

Marine Section.

Meteorologist	K. J. Kabraji, B.A. (Hons.), B.Sc. (Bombay), M.Sc., Ph.D. (London).
Assistant	1.
Clerk	1.

Instruments Section.

Meteorologist	J. M. Sil, B.A. (Cal.), B.Sc. (Engg.) (Boston Tech.).
Assistant Meteorologist	S. Mal, M.Sc., Ph.D., D.I.C. (London).
Assistants	2.
Clerks	5.
Draftsman	1.
Senior Observers	3.
Junior Observer	1.
Storekeeper	1.
Mechanics (temporary)	2.

Upper Air Section.

Meteorologist	K. R. Ramanathan, M.A., D.Sc. (Madras).
Assistant Meteorologist	S. L. Malurkar, B.Sc. (Mysore), M.Sc. (Cantab.) (temporary) (on leave).
Assistant	1.
Clerks	2.
Senior & Junior Observers	5.

Library Section.

(Including Climatology Branch.)

Meteorologist	S. R. Savur, M.A. (Madras); Ph.D. (London).
Assistant Meteorologist	V. Doraiswamy Iyer, B.A. (Madras).
Assistants	3.
Librarian	1.
Clerks	15.
Draftsmen	3.

Agricultural Meteorology Branch.

Junior Agricultural Meteorologist	L. A. Ramdas, M.A., Ph.D. (Calcutta).
Professional Assistant	R. J. Kalamkar, B.Sc. (Nagpur), B.Ag. (Nagpur), Ph.D. (London).
Senior Observers	2.
Junior Computors	3.

UPPER AIR OBSERVATORY, AGRA.

Meteorologist-in-charge	G. Chatterjee, M.Sc. (Calcutta).
Meteorologist	N. K. Sur, D.Sc. (Allahabad).
Assistant Meteorologists	K. Das, M.Sc. (Punjab), Ph.D. (London).
	S. P. Venkiteshwaran, B.A. (Hons.) (Madras) (temporary).
	S. K. Das, M.Sc. (Dacca & London) D. I. C. (*offg.*).
Superintendent	Babu Ram Saminol.

UPPER AIR OBSERVATORY, AGRA—*contd.*

Mechanical Assistant	Chain Sukh.
Chief Observer	1.
Chief Computor	1.
Foreman	1.
Clerks or Observers (permanent)	41 (at Agra).
Clerks or Observers (permanent)	62 (out-station staff).
Mechanics (temporary)	10.
Clerks & Observers (temporary)	9.
Enginemen (permanent)	2.

COLABA AND ALIBAG OBSERVATORIES, BOMBAY.

Meteorologist	B. N. Banerji, M.Sc. (Allahabad), Ph. D. (Cantab.).
At Colaba.	
Head Clerk	P. A. Rama Iyer (*offg.*).
First Assistant	1.
Observers	6.
Cashier	1.
Marine Clerk	1.
Typist & Stenographer	1.
At Alibag.	
Observers	2.

ALIPORE OBSERVATORY AND METEOROLOGICAL OFFICE, CALCUTTA.

Meteorologist	S. N. Sen, M.Sc. (Cal. & London), Ph.D. (London).
Assistant Meteorologists	A. K. Das, M.Sc. (Cal.), D.Sc. (Paris).
	S. S. Lal, M.Sc. (Lucknow & London), D. I. C. (London) (temporary).
	C. Ramaswamy, M.A. (Hons.) (Madras). (*offg.*).
Superintendent	K. P. Banerji, M.A. (on leave).
	T. N. Mitra, B.A., B.L. (*offg.*).
Professional Assistant	N. P. Chatterji, M.Sc. (Cal.).
Chief Observer	B. B. Roy, M.Sc. (*offg.*).
Met. Assistants	3.
Inspector of Observatories	1.
Clerks (Upper division)	4.
Stenographer	1.
Senior Observers	2.
Clerks Observers (Lower division)	22.
Clerks (Routine division)	5.
Junior Observers	2.
Observers (at out-stations)	5.
Printer (Press staff)	1.

METEOROLOGICAL OFFICE, KARACHI.

Meteorologist	S. K. Pramanik, M.Sc. (Lucknow), Ph.D., D.I.C. (London).
Assistant Meteorologists	P. R. Krishna Rao, B.Sc. (Mysore). B. K. Roy, M.Sc. (Calcutta).
Professional Assistant	H. R. Puri, M.Sc. (Punjab).
Meteorological Assistant	1.
Chief Observer	1.
Head Clerk	1.
Inspector of Observatories	1.
Stenographer	1.
Senior Clerks or Observers	4.
Clerks or Observers	9.
Junior Clerks or Observers	2.
Clerks	5.
Observers (out-stations)	3.

SOLAR PHYSICS OBSERVATORY, KODAIKANAL.

Director	T. Royds, D.Sc. (Lond.).
Assistant Director	A. L. Narayan, M.A., D.Sc. (Madras), F. I. P.
Assistants	3.
Recorders	4.
Mechanic	1.
Book-binders	2.

METEOROLOGICAL OFFICE, No. 3 (INDIAN) WING, R. A. F., QUETTA.

Meteorologist	A. K. Roy, B.Sc. (Cal.), B.A. (Oxon.) (temporary).
Senior Clerk	1.
Junior Clerks	3.

METEOROLOGICAL OFFICE, No. 1 (INDIAN) GROUP HEADQUARTERS, R. A. F., PESHAWAR.

Meteorological Officer (R. A. F.)	R. G. Veryard, Fl./Lt.
Senior Clerk	1.
Junior Clerks and Observers	3.

LAHORE OBSERVATORY.

Chief Observer	1.
Observers	2.

MADRAS OBSERVATORY.

Assistant-in-charge	1.
Senior Observer	1.
Junior Observers	2.

RESERVE METEOROLOGIST.

Meteorologist	S. C. Roy, M.Sc. (Cal.), D.Sc. (London), on tour to Calcutta.

OFFICERS ON LEAVE.

C. W. B. Normand, M.A., D.Sc. (Edin.).

S. L. Malurkar, B.Sc. (Mysore), M.Sc. (Cantab.) (temporary).

APPENDIX B.

PUBLICATIONS.

The following departmental publications were issued or sent to press during the year :—

I.—*Periodical.*

1. Daily Weather Reports :—
   i. Indian Daily Weather Report (to date).
   ii. Calcutta Daily Weather Report (to date).
   iii. Karachi Daily Weather Report (to date).
2. Weekly Weather Report (to date).
3. Monthly Weather Report (to date).
4. India Weather Review, Annual Summary for 1931, in seven parts :—
   i. Introduction.
   ii. Part A.—Summary of Weather and Rainfall.
   iii. Part B.—Snowfall.
   iv. Part C.—Storms and Depressions.
   v. Part D.—Annual Tables.
   vi. Part E.—Seismic Records.
   vii. Part F.—Errata to Monthly Weather Reports.
5. Daily Rainfall of India for 1929.
   Daily Rainfall of India for 1930.
6. Monthly Rainfall of India for 1929.
   Monthly Rainfall of India for 1930.
7. Upper Air Data, 1931, in 14 parts :—
   i. Parts 1—12.—Pilot Balloon and Aeroplane Data for January—December.
   ii. Part 13.—Monthly Means of Pilot Balloon Data and Monthly Frequencies of Clouds.
   iii. Part 14.—Sounding Balloon Data.
8. Seasonal Memoranda :—
   i. Memorandum on the probable character of the weather in North-West India in January, February and March 1933.
   ii. Statement of the rainfall and snowfall of North-West India in January, February and March 1932 and a comparison of the seasonal forecast with the actual precipitation.
   iii. Memorandum regarding the probable amount of monsoon rainfall in 1932.
   iv. Memorandum on the rainfall of June and July and the probable amount during August and September 1932.
   v. Statement of the actual rainfall in the monsoon season, June to September 1932, and a comparison of the forecasts with the actual rainfall.
9. Magnetic, Meteorological and Seismographic Observations made at the Government Observatories, Bombay and Alibag, in the year 1929.
   Magnetic, Meteorological and Seismographic Observations made at the Government Observatories, Bombay and Alibag, in the year 1930.
10. Report on the Administration of the Meteorological Department of the Government of India in 1931-32.
11. Annual Report of the Kodaikanal Observatory, 1932.

II.—*Occasional.*

1. Memoirs of the India Meteorological Department :—

Vol. XXV.—

Part X.—Solar Radiation Measurements at Poona in 1931, by Shanti Sroup Kohli, M.Sc.

Vol. XXVI.—

Part I.—Registration of Earth-Current with Neutral Electrodes, by Sudhansu Kumar Banerji, D.Sc.

Part II.—The Indian Southwest Monsoon and the Structure of Depressions associated with it, by K. R. Ramanathan, M.A., D.Sc., and K. P. Ramakrishnan, B.A.

2. Scientific Notes :—

Vol. V.—

No. 49.—Tables extending Walker's Criteria and for finding the Chance of Success of a Forecast, by S. R. Savur, M.A., Ph. D. and S. Gopal Rao, B.A.

No. 50.—Inversions of Lapse-Rate of Temperature, over Karachi, by A. S. Hariharan, M.A.

No. 51.—A Preliminary Study of Rainfall at Quetta, by A. K. Roy, B.A., B.Sc., and R. C. Bhattacharya, M.Sc.

No. 52.—Thunderstorms in South India during the Post-Monsoon Months October and November 1929, by S. P. Venkiteshwaran, B. A. (Hons.).

No. 53.—A Note on the Rapid Fluctuations of Atmospheric Pressure and the Atmospheric Instability at Peshawar during 1928 and 1929, by S. Basu and S. K. Pramanik.

No. 54.—A Note on Fog and Haze at Poona during the Cold Season by L. A. Ramdas, M.A., Ph. D., and S. Atmanathan, M.A.

3. Kodaikanal Observatory Bulletins :—

No. XCV.—Prominences and Radiation Pressure, by T. Royds, D.Sc.

No. XCVI.—The Variation in Area of Hydrogen Absorption Markings with Longitude, by M. Salaruddin, B.A.

No. XCVII.—Two Longitudinal Zones of Apparent Inhibition of Sunspots on the Solar Disc, by P. R. Chidambara Ayyar, B.A., F.R.A.S.

No. XCVIII.—Summary of Prominence Observations for the Second Half of the Year 1931.

No. XCIX.—On the Resonance Lines of Thallium and their Probable Absence in the Sun, by A. L. Narayan, M.A., D.Sc.

No. C.—Summary of Prominence Observations for the First Half of the Year 1932.

The following papers or notes were contributed by members of the staff to extra-departmental journals :—

Normand, C. W. B.—

Equivalent Potential Temperature—Gerlands Beiträge zur Geophysik, Vol. 38, 1933, p. 195.

Indian Rainfall Publications,—Quarterly Journal of the Royal Meteorological Society, Vol. 59, 1933, p. 156.

Banerji, S. K. and Ghatge. V. M.—

On Discontinuous Fluid Motion under Different Thermal Conditions,—Indian Journal of Physics, Vol. VII, 1932, pp. 165—228.

—— and Joshi, S. S.—

Disturbance of Pressure at the Bed of a Deep Sea,—Current Science, Vol. I, 1932, p. 6.

—— and Lele, S. R.—

Electric charges on rain drops,—Nature, Vol. 130, 1932, p. 998.

Effect of Indian Mountain Ranges on Air Motion,—Indian Journal of Physics, Vol. VII, 1932, pp. 411—425.

Ramanathan, K. R.—

A Note on the General Spectrum of the Night Sky as observed in India,—Indian Journal of Physics, Vol. VII, 1932, pp. 405—410.

Investigation of the Solar Corona without an Eclipse,—Current Science, Vol. I, 1932, p. 33.

—— and Ramakrishnan, K. P.—

Upper Air Temperatures and Humidities in the Indian Peninsula,—Nature, Vol. 129, 1932, p. 615.

—— and Karandikar, J. V.—

Non-polar Auroral Light from the night sky in the Tropics,—Nature, Vol. 129, 1932, p. 545.

Sil, J. M.—

Variations in Potential Gradient caused by some Meteorological Phenomena,—Q. Journal of Roy. Met. Soc., Vol. 59, January 1933, pp. 23—32.

False Cirrus and Atmospheric Potential Gradient,—Terr. Magnetism and Atm. Electricity, Vol. 38, 1933, pp. 66—67.

Savur, S. R.—

A simple method of determining the approximate value of a simple Correlation Coefficient,—Q. Journal of Roy. Met. Soc., Vol. 58, 1932, pp. 56—58.

On the 'Performance Test' in Statistics,—The Indian Journal of Physics, Vol. VII, 1932, pp. 27—34.

The Effect of the Indian Mountain Ranges on Air Motion,—The Indian Journal of Physics, Vol. VII, 1932, pp. 389—392.

Narayan, A. L. and Rao, A. S.—

On the Nuclear Spin Movement of the Thallium Atom,—Current Science, Vol. I, 1932, p. 75.

Ramdas, L.A.—

Agricultural Meteorology,—Current Science, Vol. I, 1932, p. 191.

—— and Malurkar, S. L.—

Surface Convection and Variation of Temperature near a Hot Surface,—Indian Journal of Physics, Vol. VII, 1932, pp. 1—14.

—— and Atmanathan, S.—

The Vertical Distribution of Air Temperature near the Ground during Night,—Gerlands Beiträge zur Geophysik, Band 37, 1932, pp. 116—117.

Desai, B. N.—

A note on the existance of critical potential characteristic of a colloid by an electrolyte,—Journal Univ. of Bombay, Vol. I, 1932, p. 25.

The importance of dialysis in colloid chemistry. Behaviour of colloids towards electrolytes and non-electrolytes with progress of dialysis,—Journal Indian Chemical Society, Special Number, 1933, p. 37.

Relation between charge and viscosity of colloidal solutions,—Current Science, Vol. I, 1932, p. 37.

Importance of dialysis in the study of colloids,—Current Science, Vol. I, 1932, p. 125.

—— and Nabar, G. M.—

Influence of Acidity of gelatine solution on its inhibitive power and on the solubility of Silver Chromate,—Journal Univ. Bombay, Vol. I, 1932, p. 28.

——, Nabar, G. M. and Barve, P. M.—

Relation between charge and stability of colloidal solutions of gold and ferric hydroxide dialysed to different extents,—Journal Indian Chem. Society, Vol. 9, 1932, p. 463.

Das, A. K.—

A New Upper Air Pressure Indicator,—Gerlands Beiträge zur Geophysik, Band 36, 1932, pp. 1—3.

A Simple Instrument for studying Temperature Inversions in the Free Atmosphere,—Gerlands Beiträge zur Geophysik, Band 37, 1932, pp. 224—232.

——, Roy, B. B., and Das Gupta, D. N.—

An Inexpensive Upper Air Temperature Indicator,—Gerlands Beiträge zur Geophysik, Band 36, 1932, pp. 4—6.

—— and Srivastava, B. N.—

Introduction to Meteorology, being a reprint of chapter XII of Text Book of Heat for Junior Students by M. N. Saha and B. N. Srivastava, Indian Press, Ltd., Allahabad, 1933, pp. 359—511.

Mal, S., Basu, S. and Desai, B. N.—

Structure and Development of Temperature Inversions in the Atmosphere,—Beiträge zur Physik der Freien Atmosphäre, Band 20, 1932, pp. 56—77.

Malurkar, S. L.—

Effect of Radiation on Surfaces of Humidity Discontinuity,—Gerlands Beiträge zur Geophysik, Band 37, pp. 410—415.

Chidambara Iyer, P. R.—

Two Longitudinal Zones of apparent Inhibition of Sunspots on the Solar Disc,—Month. Notices of the Roy. Astr. Soc., Vol. 93, 1932, pp. 150—152.

Two Longitudinal Zones of apparent Inhibition of Sunspots on the Solar Disc,—Current Science, Vol. I, 1932, p. 39.

The Structure of H_a Absorption Markings on the Sun,—Current Science, Vol. I, 1932, p. 71.

Rao, A. S. (Research Student)—

Further Investigation of the Arc Spectrum of Arsenic,—Proc. Physical Soc., London, Vol. 44, 1932, pp. 594—607.

Further Doublets of As/V,—Nature, Vol. 130, 1932, p. 630.

The First Spark Spectrum of Arsenic,—Current Science, Vol. I, 1932, p. 42.

Rao, K. R. (Research Student)—

Resonance Spectrum of Hydrogen,—Nature, Vol. 129, 1932, p. 869.

APPENDIX C.

Classification of Observatories, etc.

Meteorological or Weather Observatories.—The functions of a meteorological or weather observatory are to record the observations of such elements as can be recorded by an observer with the help of instruments on the ground (as distinct from upper air observations obtained by means of balloons, etc.). Observatories where the staff is provided and paid for by other agencies, *e.g.*, Indian States are called non-departmental although instruments are supplied by the Meteorological Department. These surface observatories are classified according to the number of observations per day and the number and kind of instruments to be read. Thus :

First Class.—Such observatories are furnished with autographic instruments for continuously recording pressure, temperature, humidity, wind direction and velocity, and rainfall, in addition to instruments read by eye. These may also undertake special observations (*e.g.*, on atmospheric electricity). The staff required varies from two part-time observers to about four full-time observers according to the amount of special work and of computation and tabulation of data.

Second Class.—At second class observatories observations are taken twice daily and usually telegraphed to one or more forecast centres. The existing standard times of observation in India are 8 hrs. (Local Time) and 17 hrs. (Indian Standard Time), the observations being made by a part-time observer on Rs. 25 per mensem. At certain II class observatories, practically all of which are non-departmental, observations are recorded twice daily, at 10 and 16 hrs. (Local Time) but not telegraphed.

Third Class.—At these observatories readings are taken daily at 8 hrs. and sent by telegram daily or by post at the end of each month to one or more forecast centres. At each observatory of this type there is one part-time observer on Rs. 15 a month.

Fourth Class.—Observations of (*a*) of temperature, wind and rainfall only or (*b*) of temperature and rainfall only are recorded at IV class observatories. At each observatory of this type there is one part-time observer on pay not exceeding Rs. 12 a month.

Fifth Class Weather Observatories.—At these observatories part-time observers on Rs. 5 p. m. record and telegraph rainfall only.

Non-Instrumental Observatories.—Observatories which do not possess any instruments but at which visual observations of *clouds, visibility,* approximate wind direction and force and weather phenomena are recorded by an observer and reported to a forecasting centre either by post or by daily telegrams. Some of these observatories are non-departmental.

Pilot Balloon Observatories.—At such observatories pilot balloons (*i.e.*, balloons without attached instruments) are released and observed through special theodolites for the determination of wind directions and velocities at various heights in the free atmosphere. The minimum staff is two full-time observers for one balloon flight per day and 3 full-time observers and a balloon maker for two balloon flights per day.

Upper Air Observatories.—Upper Air Observatories undertake in addition to observations of upper winds, those of upper air temperatures, humidities and pressures up to heights of about 15-20 miles by means of sounding balloons (*i.e.*, balloons with self-recording instruments attached).

Air Observatories.—Air Observatories are those to which Royal Air Force supply aeroplane data of temperatures and humidities upto heights of 2 or 3 miles.

Magnetic Observatory.—An observatory of this type is equipped with instruments for continuously recording the principal magnetic elements.

Seismological Stations.—Such stations are equipped with one or more continuously recording seismographs.

Time Observatories.—These are equipped with instruments for the determination of time from observations of sun and stars and from European wireless time signals.

Solar Physics Observatory.—The Department has an observatory at Kodaikanal equipped with photoheliograph, spectroheliograph, etc., where special work on solar physics is done.

Auxiliary Centre.—A centre where a Professional or Meteorological Assistant receives copies of weather reports from the forecasting centres for transmission to pilots.

Forecast Centre.—These centres are located at different meteorological offices such as Calcutta, Karachi, etc., where weather observations are collected by telegram from a number of stations in order to form the basis of weather reports and forecasts issued therefrom. These may be (*a*) Main Centres, serving a large area for general purposes, *e.g.*, the H. Q. office at Poona or (*b*) Regional Centres, serving more limited areas for special purposes, for instance, air-routes.

APPENDIX D.

ANNEX G TO CONVENTION RELATING TO THE REGULATION OF AERIAL, NAVIGATION, COLLECTION AND DISSEMINATION OF METEOROLOGICAL INFORMATION.

SECTION I.

Classification of information.

The meteorological information necessary to aerial navigation referred to in Article 35 (*a*) of the Convention may be divided, in a general way, into three categories, *viz.* :—

(*a*) Climatological information (1) which is based upon past meteorological records analysed and summarised to show the weather which is experienced in the long run at a given place or in a given area.

(*b*) Current information (2) which is based upon reports of observations transmitted to a central station by wireless, or ordinary telegraphy or telephony, and upon observations made at the centre itself. Such information gives a survey of the existing conditions at the observing stations. Current information may be divided into two categories, *viz.* :—

1. Information necessary for the preparation of synoptic charts.
2. Information necessary for the working of airways.

(*c*) Forecasts (3) which are statements of the meteorological conditions anticipated during a period of time or for an epoch of time subsequent to the time of their issue. There are two kinds of forecasts of importance for air navigation, *viz.* :—

1. General forecasts relating to an extensive area and usually for a period of 24 to 36 hours.
2. Detailed short period forecasts relating to airways.

SECTION II.

Exchange of information.

A. *Climatological information.*—1. The fundamental information as regards pressure, temperature, wind and weather, is furnished by the published monthly and annual summaries issued by the various meteorological services as far as possible in the form recommended by the International Meteorological Committee.

2. The following summaries, of great importance for aerial navigation, should be prepared for each month of the year by each contracting State, from the observations made at a selection of meteorological stations. These summaries will show :—

(*a*) The frequency of occurrence at each station of the different degrees of horizontal visibility for at least three different times a day, one in the morning, one near midday and one in the late afternoon.

---

(1) Climatological information is required

(*a*) in connection with the selection of airways.

(*b*) for indicating the variation of the meteorological conditions affecting flight during the day and the year and with the place and altitude.

(*c*) for indicating the places at which stations should be established for furnishing current information.

(2) Current information is required

(*a*) for the guidance of aviation companies and for the pilots or navigators.

(*b*) for the meteorologists responsible for the preparation of forecasts.

(3) Forecasts are required for the guidance of aviation companies and for the pilots and navigators.

(*b*) The frequency of occurrence at each station of the different heights of base of cloud for the same times as those selected for visibility.

(*c*) The frequency of occurrence at each station of winds of different directions and speeds at the surface and at heights of 500, 1,000, 2,000 and 3,000 metres.

These summaries should be prepared in the forms and for the heights and limits shown in Appendix G1 and should be exchanged through the International Commission for Air Navigation.

It is particularly important that these summaries should be prepared in those countries where no airway has yet been established, in order that concise climatological information may be available for the establishment of airways over these countries as the need for them arises.

3. Further, each contracting State is recommended to publish a " guide " conceived on lines which are essentially practical for use by airmen, presenting in a very convenient form a synthesis of climatological information useful for air navigation. The guide should also contain a table giving a list of meteorological information at the disposal of airmen at different times in the different countries.

B. *Current information.*—1. The observations should be made at hours fixed by international agreement and should be collected at regional or national centres. The reports to be exchanged in connection with the preparation of synoptic charts should be issued by wireless telegraphy at times fixed by international agreement. The reports for use on airways should be issued by wireless telegraphy at times fixed mutually by the States concerned. The issues should be made in such a way that the reports may be available to the personnel of the aviation and meteorological services with the least possible delay, duplication or interference.

2. The reports should be drawn up, as far as possible, in the form and according to the codes specified by the International Meteorological Committee. The codes recommended at present are given in Appendix G2. The symbolic form of the reports and the codes indicate the nature of the information required.

3. Current information specially supplied to aircraft in flight should be eithe in clear or in the abbreviated code given in Appendix G3. If coded information is required by a meteorologist or a navigator on board an aircraft, it should be furnished, as far as possible, in one of the codes of Appendix G2.

4. The exhibition of current information at aerodromes is dealt with in Section III below.

C. *Forecasts.*—The code for international exchange of short period forecasts on an airway appears in Appendix G10. The period covered by such forecasts will depend upon the length of the flights to be made and upon the precision with which the meteorological services can foretell the weather : it is desirable that such period should be longer than the normal duration of the flight without landing.

Section III.

Exhibition and supply of Meteorological information at Aerodromes.

The following meteorological information will be made available :—

1. A synoptic chart showing the general meteorological situation over a wide area at the time of the latest synoptic observation (Appendix G4).

2. Special forecasts of the weather at the surface and in the upper air along the different airways starting from the aerodrome. These forecasts will give prominence to phenomena affecting the safety of air navigation, such as thunderstorms, squalls, fog and the danger of ice formations at certain altitudes.

It is furthermore recommended that the forecasts which foreign services have transmitted in respect of the portion of the route above their territory should also be exhibited.

3. Warnings of sudden changes (Appendix G7).

RM/34.

Report on the Administration of the Meteorological Department of the Government of India in 1933-34.

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1934.

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List of Agents in India from whom Government of India Publications are available.

(a) PROVINCIAL GOVERNMENT BOOK DEPOTS.

MADRAS :—Superintendent, Government Press, Mount Road, Madras.
BOMBAY :—Superintendent, Government Printing and Statjonery, Queen's Road, Bombay.
SIND :—Library attached to the Office of the Commissioner in Sind, Karachi.
UNITED PROVINCES :—Superintendent, Government Press, Allahabad.
PUNJAB :—Superintendent, Government Printing, Punjab, Lahore.
BURMA :—Superintendent, Government Printing, Burma, Rangoon.
CENTRAL PROVINCES : —Superintendent, Government Printing, Central Provinces, Nagpur.
ASSAM :—Superintendent, Assam Secretariat Press, Shillong.
BIHAR AND ORISSA :—Superintendent, Government Printing, P. O. Gulzarbagh, Patna.
NORTH-WEST FRONTIER PROVINCE :—Manager, Government Printing and Stationery, Peshawar.

(b) PRIVATE BOOK-SELLERS.

Aero Stores, Karachi.*
Albert Library, Dacca.
Association Press, Calcutta.
Banerjee & Bros., Ranchi, Messrs. G.
Banthiya & Co., Ltd., Kucheri Road, Ajmer.
Bengal Flying Club, Dum Dum Cantt.*
Bhawnani & Sons, New Delhi.
Bombay Book Depot, Girgaon, Bombay.
Book Company, Calcutta.
Booklover's Resort, Taikad, Trivandrum, South India.
Burma Book Club, Ltd., Rangoon.
Butterworth & Co. (India), Ltd., Calcutta.
Calcutta Book Agency, 10-1, Shama Charan Dey St., Calcutta.
Chatterjee & Co., 3, Bacharam Chatterjee Lane, Calcutta.
Chukervertty, Chatterjee & Co., Ltd., 13, College Square, Calcutta.
City Book Co., Madras.
City Book House, Meston Road, Cawnpore.
Commercial Book Co., Lahore.
Das Gupta & Co., 54/3, College Street, Calcutta.
Deccan Book Stall, Poona 4.
Delhi and U. P. Flying Club, Ltd., Delhi.*
English Book Depot, Ferozepore.
English Book Depot, Taj Road, Agra, and Saddar Bazar, Jhansi.
English Bookstall, Karachi.
Faqir Chand Marwah, Peshawar Cantt.
Fono Book Agency, New Delhi and Simla.
Gaya Prasad & Sons, Agra.
Gopalakrishna Kone, Pudumandapam, Madras, Messrs. E. M.
Grantha Mandir, Cuttack.
Higginbothams, Madras.
Hindu Library, 137/F., Balaram De Street, Calcutta.
Hyderabad Book Depot, Chaderghat, Hyderabad (Deccan).
Imperial Book Depot, 63, Chandni Chowk Street, Delhi.
Indian Army Book Depot, Dayalbagh, Agra.
Indian Army Book Depot, Jullundur City and Daryaganj, Delhi.
Indian Book Shop, Benares City.
Indian School Supply Depot, 309, Bow Bazar St., Calcutta.
Insurance Publicity Co., Ltd, Lahore.
International Book Service, Poona 4.
Jaina & Bros., Delhi, Messrs. J. M.
James Murray and Co., 12, Govt. Place, Calcutta (for Meteorological publications only).
Kali Charan & Co., Municipal Market, Calcutta.
Kamala Book Depot, 15, College Square, Calcutta.
Kamala Book Stores, Bankipore, Patna.
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G. P. Z. P. 1934.

Tornado at Peshawar on April 5th 1933 at 12-00 hrs. (L.M.T.)

By courtesy of Leading-aircraftsman Russel Pleasants, R.A.F.

Chief Features of the Year.

The Department was called upon to shoulder the additional work and responsibility of furnishing several new Air Mail Services with weather information and forecasts. These included the Indian Trans-Continental Airways' weekly service between Karachi and Victoria Point, which constitutes a link in the Empire air route between England and Australia, the Indian National Airways Mail Services between Calcutta and Dacca and Calcutta and Rangoon, and the Madras Air Taxi Service between Madras and Calcutta. The expansion of the Meteorological Department in recent years as well as a part of the heavy retrenchment in 1932 has been bound up with the advance and lull, respectively, in the development of aviation in and across India; during the year under review, however, it happened that the growth in aviation services had to coincide, for financial reasons, with a lull in meteorological development; it was an effective reminder of the fact that when money cannot be made available, the department must do without additional forecasting centres or extra facilities, however desirable they may be. It is anticipated, however, that, as finances permit, a policy of balanced development will be pursued which in themselves will ensure improvements in meteorological services in step with advances in other facilities and services for aviation. Meanwhile this department endeavoured to maintain the skeletal meteorological organisation along each air route as efficiently as existing circumstances allowed.

Some improvements were also effected. For example, the system of current weather reports introduced during the previous year on the wireless chain along the Trans-India route was extended so as to include the immediate wirelessing of "danger" messages of adverse weather, *i.e.*, warnings of fog, gales, duststorms, etc. Schemes for putting other meteorological arrangements for aviation, including the dissemination of forecasts and upper wind reports, on a stricter routine basis were also under consideration. In connection with the Tata and Sons' Karachi-Madras Air service, the three pilot balloon stations that had been sanctioned during the previous year were opened at Malegaon, Colaba (Bombay) and Bellary, and arrangements were made to communicate current weather information by land line telegraph to certain aerodromes on that route from a few strategic points in order to supplement the weather reports from the forecasting centres whenever such information was likely to be timely and useful to the planes.

Between 1st April 1933 and 31st March 1934, 5,787 weather reports and forecasts were issued to aviators by the departmental forecasting offices at Karachi, Calcutta and Poona and the Royal Air Force centres at Quetta and Peshawar, showing an increase of about 39 per cent over the previous year, although most of the new regular services started work only during the latter part of the year. Among noteworthy flights for which forecasts were issued may be mentioned the visit to India of

the Secretary of State for Air, flights of the special high-speed Dutch and French planes in December 1933, the record-breaking flights of Sir Kingsford-Smith and Commander Ulm between England and Australia and the flights of H. E. the Viceroy and H. E. Lady Willingdon. The department helped, as usual, the candidates for pilots' " B " licence by arranging for their training and examination in meteorology at the departmental centres.

The above work on behalf of aviation represents but a part of the activities of the department. Warnings for cyclones, storms, depressions and for heavy rainfall were issued from Poona and Calcutta. Seismological and magnetic observations at Bombay, solar observations at Kodaikanal, time-service at Calcutta and Bombay, weather reports at different centres, compilation and tabulation of climatological data, exploration of the upper air by means of routine pilot balloon ascents, periodical soundings with self-recording meteorographs, the efficient working of 15 first class observatories and about 250 second and third class observatories, scattered over India, Burma, Afghanistan, Persia and Arabia—all these activities, constituting the main work of the department, were continued as usual.

Co-operation was extended to the Mount Everest Flight and the Ruttledge expedition within limits set by the financial situation and it was gratifying to note that the services of the department were highly appreciated by both expeditions.

The following extract from remarks made by Mr. L. R. Wager, a member of the expedition, during the discussion on Mr. Ruttledge's paper read before the Royal Geograpical Society, London, in November 1933 (pages 11-12, Geographical Journal, London, Volume LXXXII, No. 1), illustrates the importance of weather reports to Himalayan expeditions :—

" . . . .That [the powerful and cold wind] then is the difficulty of climbing Mt. Everest very early in the year and the snow is the difficulty which arrives later. Can therefore the Meteorologist in Calcutta be depended upon to give us warning as to when the monsoon, which brings the snow, is going to occur ? This year, Dr. Sen, of the Meteorological Office in Calcutta, sent us daily weather reports, and of course being in a mountain region, we did not at first believe those reports at all. Then we began to realise that Dr. Sen's reports were actually forecasting the weather about two days before it actually came. He also told us when the monsoon was likely to occur ; but that seemed so ridiculously early that we could not believe that either. Nevertheless he was right. In future I think we must accept what the Meteorologists tell us, and make our arrangements accordingly. "

Towards the end of his leave in Europe, the Director General of Observatories attended on deputation the International Meteorological Committee meeting held at De Bilt, Holland, from October 4th to October 7th, 1933. This committee, elected by the International Meteorological Conference once in six years, ordinarily meets only once in three years, but more frequent meetings became necessary between 1930-33 in connection with arrangements for the International Polar Year work. The most important subject discussed at some length in the meeting of the committee concerned the action already taken, and still to be taken, in connection with the documentation and discussion of the world-wide

observations made during the Polar Year. Under the general heading of meteorology over the ocean, two subjects were discussed that were of special interest to India. One concerned the Indian Ships' Weather Code and the other the storm signals proposed for the China Sea coasts. The Indian Ships' Weather Code is a modification, in certain respects which are considered locally important, of the International Code. The Maritime Meteorology Commission, 1932, was however strongly opposed to any such departure and the recent meeting of the International Meteorological Committee expressed itself in favour of a uniformity of Codes all over the world. In India one main difficulty has been financial, because the use of the International Ships' Code would raise telegraphic costs—a consideration which has made its immediate adoption impossible hitherto ; at the same time, it would not include every item of information which this department requires from ships.

Another matter of interest was the communication made to the Committee about the concessions accorded to meteorological telegrams in the new International Telegraph Convention adopted in Madrid in 1932. The Indian Posts and Telegraphs Department have, according to this convention, notified a reduction in the charges for foreign meteorological telegrams, and a similar concession is likely to be accorded in respect of meteorological radio telegrams from and to ships.

By way of exploring the possibility of exchange of meteorological data by wireless between India and the neighbouring countries, a further series of trial broadcasts between Calcutta and Hanoi was arranged for ; Singapore was also asked to listen in to these broadcasts. Results of these trials and further discussion with the Director of Wireless as to the possibility of issuing broadcasts from Rangoon instead of Calcutta show that, with the present wireless equipment, the exchange of data with Singapore and proper reception of Calcutta data at Hanoi are impracticable, that the exchange of data between India and Siam can be effected with the help of the existing landline or shortwave wireless service, and that arrangements can be made to receive Hanoi data at Calcutta. The matter is still under consideration.

On account of financial stringency, the resumption of the intensive study of weather in northeast India in the nor'wester season had to be postponed once more and inspections of observatories curtailed considerably. For the same reason building schemes at the Agra and Kodaikanal Observatories were held up. By agreement with the Bombay Chamber of Commerce and the Department of Agriculture, Bombay, it was also decided, for financial reasons, to discontinue the collection and the printing of the bi-weekly crop data that used to be issued with the Bombay Daily Weather Report.

A fair amount of progress was also maintained in the investigational activities of the department. At Agra 83 sounding balloons were released. Study was made of some features of depressions originating in the Bay of Bengal during the southwest monsoon and of the humidity records obtained with hair elements and with wet and dry bulb elements in a Dines' meteorograph. At Bombay advantage was taken of the

searchlight operations of the Bombay Electric Supply Co. to obtain observations of the heights of cloud base at night. The Meteorological Officer at Peshawar investigated, in co-operation with the medical authorities, the meteorological conditions favourable for heat stroke and for diseases like malaria and sandfly fever ; the rainfall of Peshawar and a tornado that occurred at Peshawar in April formed other subjects of his study ; a picture of this tornado, the first to be photographed in India, is given as the frontispiece of this report. The Meteorological Officers at Quetta and Peshawar jointly studied meteorological conditions affecting aviation over the northwest frontier. The Headquarters Office at Poona regularly released sounding balloons except during the monsoon when they were released at Madras and proved, by the high percentage of subsequent recovery of instruments, how favourably situated Madras is for work of this type. The results of sounding balloon ascents made at Poona and Hyderabad during 1928-31 were analysed and discussed in a paper which is in press for publication as a departmental memoir. Statistical studies mainly directed towards grouping the various rainfall divisions of India into units homogeneous for purposes of foreshadowing precipitation were carried out. The remaining investigational work that was undertaken in the Poona Office was rendered possible by the presence of some voluntary research students, working under the guidance of Meteorological Officers. For example, arrangements were made for setting up an apparatus for the continuous registration of earth-air electric current. Work was in progress on the measurement of the feeble electric charge associated with drops of various liquids produced by spraying under identical conditions ; it is considered that those experiments will throw considerable light on the process of generation of charges on drops. Some experiments were also made on the vortices formed on the discontinuous boundary between gases at different temperatures. An investigation was made of the properties of the air layer next to an evaporating surface. Further studies were made on the light from the night sky. Experiments have been commenced on the response of hair and other hygroscopic material to sudden changes of humidity. A set of experimental snowgauges was designed and sent to Quetta for exposure during winter with a view to evolve a standard design for the department. High lapse rates of temperature and their diurnal variation in the surface layers of the atmosphere over northern India were studied. Investigations of sizes of fog and rain droplets and of temperature of rain were made at Khandala. The Agricultural Meteorology Branch was engaged in a study of cotton statistics in the Bombay Presidency and adjoining cotton areas in relation to weather factors, as well as in various experimental items of work, including the measurement of solar, terrestrial and nocturnal radiation, of evaporation and the temperature of air, soil and plant.

No description of the Chief Features of the year under review would be complete without a reference to the most outstanding natural phenomenon of the year, *viz.*, the devastating earthquake disaster that befell Bihar on the 15th January 1934. As the department is responsible for maintaining seismological instruments and interested to some degree in

geophysical studies, the Bihar earthquake and the seismological records obtained in the department formed a subject, to the study of which some of the officers devoted considerable thought. Most of the seismographs in the department failed to provide satisfactory records of the shock, because they were thrown out of action by the violence of the early vibrations. The sensitive Milne-Shaw instruments were not damaged in any way but the couplings between mirror and boom were dislodged, and the question of preventing such a happening in future by suitable mechanical devices is under consideration. The only complete seismograms that were obtained were those from an Omori-Ewing instrument at Colaba. It is interesting to note that the marking clock of the latter seismograph at Colaba stopped working after the 5th minute mark from the beginning of the great shock and this appears to be associated with the incidence of the principal maximum phase in the *long* waves. In Calcutta some of the Standard Clocks (Riefler and Agar Baugh) stopped during the earthquake; others (Kullberg and Dent) did not stop but jumped through 36·7 and 2·7 seconds respectively. The disaster drew attention to the need for a more intensive study of seismology in India. The Bihar and Orissa Government had under consideration the question of seismological stations being established in or near the seismic belt in their province and consulted this department in the matter.

Marine Meteorology—Storm Warnings.

The system of storm warnings for ports and shipping.—No change was introduced into the system during the year under report. Warnings for the Bay of Bengal area continued to be issued from the Calcutta Meteorological Office and those for the Arabian Sea area from the Poona Meteorological Office. The number of ports on the warning list was 39 on the west coast of India and 30 around the Bay of Bengal as against 38 and 30 respectively in the previous year. The latest weather information was supplied as usual to shipping at sea by means of weather bulletin issued regularly twice a day from the coastal radio stations and more frequently, sometimes as often as six times a day, when the weather situation demanded. The number of such broadcast messages issued by the Calcutta Meteorological Office during the year was 2,186 as against 2,030 in the previous year and the number issued by the Poona Meteorological Office, 1,265 against 1,196 during the previous year. As an instance of appreciation of the broadcasts issued may be quoted the remarks of Captain of S. S. "Nurjahan" of the Asiatic Steam Navigation Co., in respect of those issued during the severe cyclone of 13th to 17th November 1933: "The information given by Alipore was most accurate and a great help".

Services to ports around the Bay of Bengal.—Warnings were issued for 24 periods of disturbed or suspicious weather. Out of these, on 7 occasions the disturbances developed into storms of which the most severe was the one that occurred between the 12th and 17th December 1933.

Pressure fell in the southwest Bay of Bengal to the east of Ceylon between the 9th and 11th and by the 12th morning a depression had formed with central region in the neighbourhood of Lat. 7½°N, Long. 85½°E. During the course of that day the depression intensified and was a storm by the evening, centred within half a degree of Lat. 8½°N, Long. 85°E. Winds of gale force were reported on the 12th afternoon by S. S. "Jalaveera", S. S. "Barjora" and S.S. "Goalpara" within a distance of about 150 miles from the centre of the disturbance. The storm moved slowly in a northwesterly direction intensifying further at the same time within half a degree of Lat. 10½°N, Long. 82°E on the 14th morning; at this time the storm was of severe intensity. Continuing to move very slowly in the same direction, the severe cyclonic storm was centred about 100 miles to the southeast of Cuddalore at 23 hrs. on the 14th. With the approach of the cyclone, winds along the Coromandel coast strengthened and squalls also began to be experienced at the ports on the coast. The cyclone took thereafter a more westerly course and crossed the south Coromandel coast near Porto Novo (slightly south of Cuddalore) on the 15th evening. From the reports of the Cuddalore Port Officer it appears that northeasterly gales were experienced there between 10 A.M. and 4 P.M. of the 15th and an easterly hurricane between 5 and 6 P.M. of that day. The easterly wind blowing direct from the sea caused, in an hour's time, a sudden rise of water of about 6 feet above high water spring tides, inundating the whole of the lower ground on the sea coast and causing tremendous damage. The rivers Gadilam, Uppanar and Paravanar resembled a rough sea. Easterly to eastsoutheasterly winds of hurricane force continued to blow till 11 P.M. after which the wind fell down rapidly. The storm wave also receded as rapidly as it rose and by about midnight it had more or less completely receded. So long as the wind was blowing hard, there was not much rain, but heavy rain fell after the midnight of the 15th as a result of which there were floods in the rivers Paravanar and Gadilam. It appears that the pressure deficiency near the centre of the cyclone at the time of its passage inland was at least 1·00". After crossing coast, the storm weakened rapidly and lay as a depression over southeast Madras on the 16th. The depression filled up there on the next day.

The cyclone caused widespread rain in southeast Madras and Mysore between the 14th and 16th, rainfall being specially heavy in the Nellore, Madras, Chingleput and Arcot districts. According to newspaper reports, heavy rain and strong winds in connection with this cyclone caused severe floods resulting in considerable damage to telegraph and railway lines as well as to crops and property in the Madras, Chingleput and Arcot districts. It is reported that some lives were also lost and a train was thrown off the rails near Cuddalore by strong winds.

An extract from the Cuddalore Port Officer's letter dated 4th January 1934 in regard to this storm may be quoted :—"The meteorological weather warnings were timely and very useful until they suddenly ceased due to breakage in telegraphic communication. A copy of the danger warnings was sent from this office to the Collector, District Superintendent of Police and all Shipping Agents on the 14th (December):

On these warnings, action was taken by the District Collector to inform the public throughout the South Arcot District and it was due to this that there was no loss of life."

Thirty-one Port Officers sent their remarks on the warnings issued to them during the year and nearly all of them expressed satisfaction with the warnings received by them. Criticisms or remarks on individual warnings issued and other suggestions from Port Officers are always carefully considered. The number of warnings issued to ports by the Calcutta Meteorological Office was 5,286 as against 4,638 in the previous year.

Services to Arabian Sea Ports.—Warnings for disturbed weather were issued on 29 occasions ; on one of these occasions the disturbance developed into a storm.

Thirty-two Port Officers sent their annual returns about warnings sent to them, and expressed satisfaction with the warnings and with the existing system for their issue. There were no criticisms of importance of the individual warnings issued. The number of warning messages issued to ports from the Poona Meteorological Office during the year was 3,536 as against 3,422 during the previous year.

Exchange of information with ships at sea.—The chief sources of marine data are wireless weather messages from ships at sea and extracts from weather logs of ships calling at the principal ports on the Indian seaboard. The object of the system of radio messages from ships is to help in increasing the efficiency of cyclone warnings. The system which was started in 1914 was suspended during the War, but resumed in 1921. Since that year there has been a steady increase in the use of this system by ships in Indian waters. The following figures show the number of ships' messages from the Bay and the Arabian Sea during the year under report as well as in the previous years since 1922 :—

Year.	Ships' messages.	Year.	Ships' messages.
1922-23	656	1928-29	4,342
1923-24	2,237	1929-30	4,635
1924-25	3,633	1930-31	5,869
1925-26	3,689	1931-32	6,971
1926-27	4,282	1932-33	10,010
1927-28	4,835	1933-34	10,814

The figures show a most gratifying increase from year to year indicating a large amount of willing co-operation from the ships' Captains. It is not possible to name here every steamship that sent messages, but

those that sent 50 messages or more during the year are listed below along with the number of messages received from each :—

Name of ship.	No. of messages.	Name of ship.	No. of messages.
1. Aungban	211	28. Haresfield	71
2. Aronda	78	29. Investigator	57
3. Arankola	95	30. Jalapalaka	132
4. Badarpur	239	31. Jaladurga	73
5. Begum	124	32. Jalabala	95
6. Barjora	81	33. Jalamohan	77
7. Binfield	90	34. Jalarajan	78
8. British Sailor	57	35. Jaladuta	116
9. British Soldier	103	36. Jalajyoti	76
10. British Sovereign	60	37. Jalatarang	101
11. Carthage	61	38. Jalavijaya	69
12. Chilka	95	39. Jalaveera	163
13. Corfu	100	40. Karagola	104
14. Cranfield	100	41. Kaiser-I-Hind	56
15. Dara	94	42. Karoa	108
16. Ethiopia	206	43. Khandala	148
17. Ekma	102	44. Masimpur	270
18. Erinpura	170	45. Maharaja	71
19. Egra	84	46. Rizwani	138
20. Ellenga	54	47. Rohna	116
21. Gazana	61	48. Rajula	189
22. Gandara	72	49. Sikh	67
23. Golconda	99	50. Singu	177
24. Ganges	50	51. Sirdhana	61
25. Gharinda	65	52. Suisang	56
26. Havildar	100	53. Sirsa	64
27. Hosang	70	54. Victoria	50

The second principal source of marine data for purposes of study is the log extracts collected by clerks in Calcutta and Bombay and the other agencies mentioned below. The British India Steam Navigation Company, the Scindia Steam Navigation Company, the Burma Oil Company Limited, Rangoon, and the Asiatic Steam Navigation Company have standing arrangements with a number of their ships' Captains to copy and despatch extracts from weather logs in two kinds of forms, which are supplied to them for use during ordinary weather and during disturbed weather respectively. The Port authorities at Rangoon also continued to render help by allowing the observers of the Time Ball and Tidal Observatory of the Port Commissioners to collect ships' data. Occasionally, in special cases of interesting disturbed weather, logs of steamers were collected through the help of the Colombo Port authorities. A total of over 4,700 logs was recorded during the year.

Inland Weather Warnings and forecasts.

Inland Weather Warnings and Forecasts.—The majority of officers to whom warnings of heavy rain on land are issued from Poona and Calcutta were district officers and officers of the Irrigation, Railway and other Departments. The number of officers on the Poona Warning List was 149. The number of officers on the Calcutta Warning List was 146 including 16 officers of the Telegraph Department (who generally require warnings for strong winds), 8 river ports, 11 river police stations, 43 district police stations and 3 revenue sub-divisional officers. The Calcutta list of great danger warnings contains the names of 461 officers including the 43 district police stations mentioned above. In addition to these specific warnings to individual officers the Daily Weather Telegraphic Summary contains heavy rainfall forecasts and all its subscribers thus receive warnings. During the year under report the forecasting centres issued 8,500 inland warning messages including great danger warnings, special weather bulletins for river craft and warnings of probability of thunder-squalls in Bengal, while 752 telegrams of heavy rainfall were sent direct to various officers by local Meteorological Observers. Reports on the working of the inland warning system were received from 104 officers all of whom expressed general satisfaction with the warnings issued. The following appreciations are noteworthy :—

The Secretary to the Agent to the Governor-General in Gujarat States and Resident at Baroda wrote on 14th August 1933—

"The Resident has been away ..... but I am sure he would desire to thank you for the excellent forecasts of weather we have had during this month. The telegrams were most helpful and certainly prepared us for the flood which came to Baroda on the 11th-12th and which rose to within 3½ ft. of the big 1927 flood."

Messrs. McNeill and Company, Joint Agents, British India Steam Navigation Company, Barisal Agency, wrote on 4th August 1933—

"Your telegrams (weather) have been extraordinarily accurate."

The Officer-in-charge, District Police Station, Magura, wrote on 1st January 1934—

"Warnings issued from time to time were effective. None went wrong. The warnings are fully appreciated by me. These enabled me to warn the public from the danger. I cannot suggest any opinion which will make warnings more effective."

A few officers had minor criticisms to offer about individual forecasts of heavy rain not proving correct or not being received in time. For instance, the Conservator of Forests, Working Plans Circle, Naini Tal, pointed out that—

".....two periods of heaviest rainfall (July 4-6 and 23-24) had no warnings while some periods of very mild rainfall, for example, August 22-24 and September 21 and 25 had warnings."

Such criticisms are very useful inasmuch as they help the department to take such practical steps as may be possible to improve its organisation.

Aviation forecasts and weather reports.—The Meteorological Offices at Karachi and Calcutta continued to share responsibility for the forecasts issued to aviators on the main trans-India air route. The Quetta

and Peshawar Offices, as usual, took part in the supply of forecasts to the Royal Air Force 'planes. The Meteorological Office, Poona, issued forecasts for aviators in South India including the Tata Air Mail between Ahmedabad and Madras. Besides the regular air services, route forecasts were supplied on requisition to various individual fliers, members of the Indian Flying Clubs and Royal Air Force Flying Squadrons.

The considerable increase in the demands of aviation on this department on account of the starting of several new air mail services during the year has already been referred to in the opening paragraphs under the Chief Features. It was very gratifying in these circumstances for the department to find that its services were appreciated by aviation interests.

The Commander of the Royal Air Force long-distance flight from Iraq to Singapore in January-February 1934 mentioned in his report that—

"The meteorological information was excellent, forecasts being received at every stopping place and being very accurate for the next day's flying. During flight upper wind information was received from nearly every meteorological station and proved of the greatest assistance."

The Aerodrome Officer, Dum Dum, said on the 20th December 1933—

"The forecasts issued in connection with the flight of H. E. the Countess of Willingdon from Samalkot to Calcutta were perfect."

Commander Ulm intimated through the Officer-in-charge, Karachi Air Port, that the meteorological forecasts over the Indian Section (furnished him in connection with his record breaking flight) were extremely accurate and that these, including the forecasts about monsoon and upper winds, had been of very great help to him.

Mr. Lynch-Blosse, Pilot of the "Cruiser", wrote in an article that—

"We sneaked out of Madras on the tail end of the cyclone which had deposited 17" of rain on our air-craft, climbed up the hills through layers of cloud, and came out into clear weather 200 miles from Bombay. Here may I give thanks to Weather Office at Poona which gave me excellent reports while I was at Madras" (Extract from page 62 of "The Aeroplane", Vol. XLVI, No. 2, dated 10th January 1934).

A few aviators complained about the late receipt of upper wind data. The supply of these has been expedited as far as present organisation would allow. The complaints, however, were largely due to incomplete understanding of the existing weather organisation and its limitations; this constitutes a strong argument for placing the issue of all pilot balloon data and forecasts on a routine basis, and steps were taken to achieve this end.

The total number of aviation forecasts issued during the year was 5,787 of which Karachi was responsible for 3,949, Calcutta for 1,008; Poona for 384, Quetta for 219 and Peshawar for 227. The number of upper wind reports, special current weather reports and voluntary

warnings of dangerous weather and improvement thereof issued by observers along the chain of current weather stations is given in the following table :—

Name of Station.	No. of upper wind reports supplied.	No. of special current weather reports supplied.	No. of danger met and improvement messages issued between 1st July 1933 and 31st March 1934.
1. Karachi	1,447	44	46
2. Jodhpur	..	97	4
3. Delhi	..	39	2
4. Allahabad	183	83	17
5. Calcutta	159	93	59
6. Chittagong	..	162	12
7. Akyab	126	277	50
8. Sandoway	7	235	14
9. Bassein	..	294	6
10. Rangoon	234	248	12
11. Victoria Point . . .	137	21	18

Further, 16 special current weather reports in addition to 500 routine reports were supplied to the Tata Air Mail Service between Karachi and Madras.

Offices and Observatories.

A list of the staff of the India Meteorological Department as it stood on the last day of the year under review is given in Appendix A. The 1934 edition of the pamphlet on Functions and Organisation of the India Meteorological Department was prepared and sent to the Department of Industries and Labour for publication. The 21st Session of the Indian Science Congress was originally arranged to take place at Poona, but, due to the prevalence of plague in Poona, the venue was ultimately shifted to Bombay. The Department deputed a few officers, including Mr. Sohoni who was one of the honorary local secretaries of the Congress, to attend the meeting at Bombay.

Headquarters Office, Poona.—The chief features contain a mention of a part of the scientific work done in this office. The colloquium for the discussion of scientific subjects held 15 meetings during the year. As in the previous year, a limited programme of work was undertaken in connection with the International Polar Year; and arrangements were made for the collection, scrutiny, tabulation and editing of all observations made in India for the Polar Year Commission. The situation created by the rapid expansion of aviation during the year was one of the main subjects engaging the attention of the office. The working of each section of the office is described briefly below.

(*a*) *General Section.*—This section deals with matters affecting the administration of Headquarters and Sub-offices, including such headings as budget and accounts, establishments, general registry and technical questions involving fresh expenditure as well as arrangements for the co-ordination of the technical work of the department.

During the year recommendations were submitted to Government regarding revised rates of pay for new entrants to the subordinate services in this Department and Government orders were received on the subject.

Arrangements for services to aviators gave rise to a considerable amount of correspondence and additional work in the section. In addition to the inclusion in the Current Weather Scheme of immediate reports of adverse weather and its improvement, three extra routine observations at 10, 15 and 17-30 hrs. daily were arranged for at all the observatories taking part in the current weather scheme; these are in addition to the two routine observations in the early morning and at noon that are exchanged by wireless. These additional observations which are merely for record until the Wireless Department can handle the extra traffic involved are expected to yield statistics valuable from the point of view of the aviator. The possibility of arranging other weather reports such as upper wind and low cloud messages and forecasts on a routine basis by transmission along the air-route wireless chain at fixed times daily was under consideration. New forms for weather logs to be recorded by pilots of regular air services were introduced.

It was learnt during the year that, on account of financial stringency the Government of India have withdrawn from the Membership of the International Union of Geodesy and Geophysics and of the Union of Astronomy and have decided not to seek admission into the Unions of Geography, Radio Telegraphy and Biological Sciences and that as a consequence, the question of formation in India of a National Research Council and National Committees put forward in 1930 by the Government of India has been given up for the present. The Union of Geodesy and Geophysics has sections on Meteorology, Seismology and Terrestrial Magnetism in which this department is interested and the Director-General of Observatories spent a part of his leave in Lisbon in order to attend the Union's meeting there in September 1933. The department suggested to Government to forward a draft resolution for consideration by the General Assembly of the International Council of Scientific Unions, whereby the existing system of fixing contributions from adhering countries

according to population could be replaced by a more pliable or vountary system of contribution, as in the Universal Postal Union or International Meteorological Organisation.

(*b*) *Weather Section.*—The previous pages dealing with storm and heavy rain warnings have partly exemplified the functions of this Section, which is responsible for the issue of the daily weather telegrams that appear regularly in newspapers, the Daily, Weekly and Monthly Weather Reports and for the preparation of portions of the Annual Summary of the India Weather Review. During the year, the additional responsibility of issuing aviation forecasts on the Madras-Puri Section of the Madras-Calcutta Air Service was undertaken by the Section, which had to continue working under the handicap caused by the absence of an afternoon weather chart.

Arrangements for current weather reports similar to those made during the southwest monsoon on the Ahmedabad-Poona-Bellary Section were made during the northeast monsoon period on the Madras-Bellary-Bombay Section of the Madras-Karachi air route. A note on the climatology of the air route Rawalpindi to Srinagar during June to September was prepared and supplied to the Bombay Flying Club. A climatological note about the surface and upper winds for December along Calcutta-Madras route, a climatological note on the northeast monsoon period of 1932 along the Bellary-Madras route and on the southwest monsoon period of 1933 along the Ahmedabad-Poona route and a third note showing particulars about rainfall, number of rainy days, frequency of heavy rainfall and thunderstorms and cloudiness along the two alternative routes Bellary-Bangalore-Madras, Bellary-Cuddapah-Madras were supplied on request to Tata Sons, Limited, Bombay.

In connection with the selection of the aviation routes along the Burma coast normal rainfall charts together with an explanatory note about the movement of depressions between Singapore and Calcutta were supplied to the Director of Civil Aviation in India at his request.

The Weather Message Code, 1931, was revised and sent to press for the printing of a second edition.

(*c*) *Observatories Section.*—This Section administered and arranged for the inspection of the departmental observatories in south and central India. The prevailing financial stringency curtailed the amount of inspection of observatories that could be undertaken during the year, only 24 observatories being inspected. One third-class observatory was started and one third-class non-departmental observatory closed. The 1929 edition of the Instructions to Observers was revised and sent to press. Part I of the new edition of the Handbook of Observatories was completed.

Arrangements were made for seven observatories along the Himalayas to telegraph their observations to Calcutta during the progress of the Mount Everest Expedition.

(*d*) *Instruments Section.*—The Section continued to be responsible for the purchase, test, standardisation and repairs of meteorological instruments and their issue to all surface observatories of the department as well as for the supply of forms and stationery to them. In pursuance of the general aim to organise the routine work of the section on a systematic basis, special departmental forms were designed and existing forms modified. Store-keeping and accounting of stores were re-organised.

During the year under review 526 instruments were issued to departmental observatories, 56 instruments loaned, 1,599 instruments tested and 266 instruments repaired. The policy of replacing very old self-recording instruments by standardised ones was continued. Wind-vanes and anemometers of old types were also being systematically replaced by standardised instruments made or remodelled in the departmental workshops, a total of 77 windvanes and 161 anemometers being thus replaced by the end of the year. Kew Pattern station barometers made to departmental specifications were also introduced at 16 stations. A complete set of meteorological instruments including an I. M. D. anemometer specially adapted for electrical registration was issued to H. M. I. S. " Investigator " for regular observations during her cruise.

Work in connection with the maintenance of self-recording instruments at high level stations and with measurements of the atmospheric electrical elements at Poona for the International Polar Year was continued. Suggestions were forwarded to the India Store Department, London, for improvements in the design of aeroplane strut psychrometers. Tests were undertaken with experimental maximum thermometers to find out the causes for their occasional failures to register the maximum temperatures. Specifications were drawn up for instruments of special range for use at high level stations, and a general re-examination of departmental specifications was undertaken with the object of improving them wherever experience gained during past years indicated a necessity for revision.

Requests for information regarding specifications, installation, etc., of meteorological instruments, numbering over 50, were complied with.

(*e*) *Marine Section.*—The usual duties of the Section namely the co-ordination of the work of collection, examination and study of ships' weather logs and of maintaining contact with the shipping interests at Bombay were carried on satisfactorily. Copies of all meteorological observations by ships in Indian waters between August 1932 and March 1933 inclusive were sent to the Deutsche Seewarte, Hamburg, for inclusion in the daily weather maps of the northern hemisphere that are being prepared for the International Meteorological Committee. An extended programme of marine meteorological observations was drawn up and communicated to H. M. I. S. " Investigator " ; the necessary additional instruments were installed and regular observations began to be received from the ship from November 1933.

Arrangements were made through the courtesy of H. E. the Naval Commander-in-Chief for wirelessing to this department the results of all pilot balloon ascents and posting the observations of upper air temperatures and heights of low clouds taken by H. M. ships in Indian waters. Essays in meteorology by cadets of the I. M. M. T. S. " Dufferin " were judged as usual and a prize of an aneroid was sent to the Captain Superintendent for presentation to the cadet who stood first in meteorology. The question of changing the hours at which ships at present take and wireless special observations was under consideration.

(*f*) *Upper Air Section.*—Sounding balloon work was carried on regularly at Poona except during the monsoon season, in which period regular ascents were made only at Madras. During the year, 128 meteorographs were let off, of which 86 have been recovered. This constitutes, for India, a good percentage of recoveries and is due entirely to the temporary change of centre for this work from Poona to Madras. At Madras as many as 52 out of the 65 instruments liberated, or 80 per cent., were recovered. Observations of upper air temperatures and humidities continued to be made from aeroplanes by the Royal Air Force at Peshawar, Quetta and Karachi and the data were worked out at Poona in a form suitable for publication; the results from January 1929 are included in the monthly publication of Upper Air Data.

In order to obtain information about the heights at which low clouds occur during the monsoon season, regular " ceiling " balloon ascents were made at Bombay and Poona during the months June to September and arranged for at Madras from the beginning of October. The study of upper air conditions in normal and disturbed weather was continued.

Other investigational activities of the section and its officers have been mentioned under the Chief Features.

(*g*) *Library Section.*—The duties of the Section comprise the care of the library, the editing and distribution of departmental publications, the supply of climatological and general meteorological information in reply to enquiries, the issue of the seasonal rainfall forecasts and the carrying on of statistical studies relating to them.

The number of books, pamphlets and periodicals either purchased or received in exchange for the publications of the department or as complimentary copies was 757. One Memoir, one Monograph and three Scientific Notes were published during the year and the routine publications issued as usual. Appendix B gives a list of the publications issued by the Department as well as of papers and contributions by the members of the staff to non-departmental journals, Indian and foreign. The number of addresses on the free distribution list of departmental publications was 372 at the end of the year. About 400 enquiries for climatological and meteorological information were answered. The usual seasonal forecasts were issued.

Some progress was made in the shelf-listing of the books and periodicals in the Library. Statistical studies included attempts to explore the possibility of foreshadowing winter precipitation in the various subdivisions of northwest India for monthly periods and of improving the

reliability of the existing forecast formula. The *performance test* was used with great advantage to group the various factors used for foreshadowing purposes in the order of decreasing reliability. The possibility of applying periodogram analysis for the purpose of forecasting rainfall was being explored.

The routine activities of the Climatological Branch which consist of scrutinising the accuracy of records of surface meteorological data, preparation of meteorological tables for the routine publications of the department and supply of periodical meteorological reports and data to various Government and Public Officers were carried on satisfactorily.

The usual advisory functions of the Director-General of Observatories with regard to the registration of rainfall, inspection of rain gauges and the publication of the provincial rainfall tables were also carried out. Arrangements were being made for the collection and publication of rainfall statistics of those Indian States in the Bombay Presidency, the Central Provinces and Bihar and Orissa, which have recently been placed in direct political relationship with the Government of India.

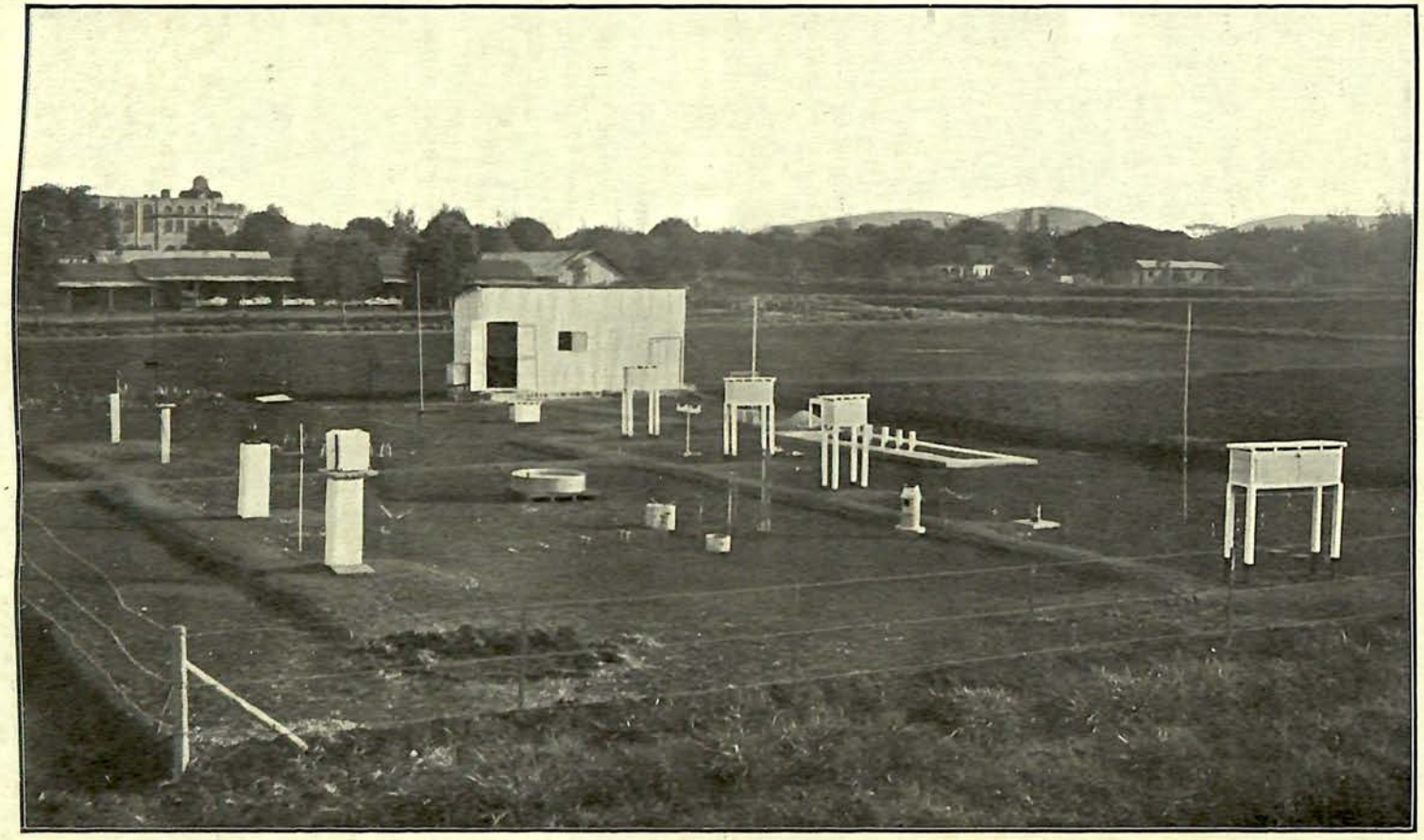
History sheets of 43 observatories were prepared. Percentage wind frequency normals of 59 stations were calculated.

(*h*) *Agricultural Meteorology Branch.*—This Branch which began to function during the previous year made progress in organising preliminary work at Poona on different aspects of the subject of Agricultural Meteorology.

The programme on the "experimental" side included precision observations on the growth of wheat and on the study of the microclimate of that crop during the last Rabi season and a study of (1) the "micro-climate" within the first few feet above the ground in the open, (2) the "micro-climate" inside crops, (3) the "thermal balance" at the surface of the ground, (4) evaporation from soil and free water surfaces, (5) radiation from the sun, the sky and the earth's surface, (6) soil temperature in relation to soil colour and moisture at the surface and lower depths, (7) percolation of water through different depths of soil, (8) exchange of moisture between air and soil during clear weather and (9) meteorological factors in relation to incidence of frost during winter in India. The results of some of the studies referred to above are being discussed in a series of papers.

Most of these investigations were conducted at the Central Agricultural Meteorological Observatory situated in the farm of the Agricultural College, Poona. The installation of the various instruments was completed by December 1933. A photograph of the Observatory is seen opposite to this page.

Attention was also paid to the design and construction of evaporimeters, percolation gauges, thermo-couple installations for the



Agricultural Meteorological Observatory, Poona.

measurement of air, soil and plant temperatures, portable screens for the installation of thermometers inside crops and a few other instruments. Experience was gained in methods of observation suited to a study of crops in relation to weather and a draft schedule on Crop-Weather precision observations was circulated to various agricultural workers for remarks and criticisms.

The Statistical Section of the Branch was mainly engaged in (1) a preliminary study of weather in relation to the cotton yields in the districts of the Bombay Presidency, (2) the analysis of data of some of the experimental farms in India, (3) the analysis of the "experimental" data collected at the Agricultural Meteorological Observatory at Poona, (4) the statistical analysis of meteorological factors for forecasting maximum temperature, (5) the calculation of evaporation in different months from other meteorological factors at about 100 representative stations in India and (6) the analysis of the precision observations on wheat. Some of the results have been discussed in a few papers which will be published shortly.

Besides the pioneer work undertaken at the Central Agricultural Meteorological Observatory at Poona, the co-operation of the Branch was freely extended to various Agricultural Departments or institutions for initiating work on similar lines. Advice regarding suitable meteorological instruments, standard methods of installing and taking observations from them was given to about 25 Agricultural Institutions or workers in India. Instruments received from four of the above were also standardised after minor repairs.

The Agricultural Meteorologist arranged with the Weather Section for the issue of frost warnings during last winter to the Nasik area where grapes are grown extensively. These warnings are reported to have been useful to the grape growers and much appreciated by them as they could take precautionary measures.

Mention may also be made of the co-operation extended to officers in charge of the Sugarcane and Dry Farming Schemes in Bombay, the Locust Research Scheme in Baluchistan, the Cereal Rust Scheme, and the Cotton Research Scheme at Coimbatore and Sakrand. To facilitate uniformity of work at different Agricultural Centres, it was decided to publish a suitable Agricultural Meteorology Hand-Book, a first draft of which was completed towards the end of the year.

The United Provinces Government deputed Mr. Sripal Singh and the Mysore Government Mr. Anantapadmanabha Rao for training in Agricultural Meteorology. Besides the above, numerous agricultural workers visited the observatory in order to see the equipment and methods of observations; in all, about 320 visitors were shown round the observatory during the year.

Five Science Graduates were also carrying on research work under the guidance of the Agricultural Meteorologist.

Upper Air Observatory, Agra.—This observatory administers all the pilot balloon stations of the department except those at other departmental centres such as Karachi, Calcutta or Poona. Three new pilot balloon stations were opened during the year. The pilot balloon stations which had been temporarily shifted to Purnea and Darjeeling in connection with the Everest Expeditions were shifted back to Patna and Dacca. 209,120 Cub. ft. of hydrogen were prepared during the year for use at the pilot balloon stations.

For financial reasons, the scientific activities of the observatory continued somewhat restricted. 83 sounding balloons were sent up and 50 recovered, many of them having penetrated the stratosphere. An apparatus for quick calibration of thermographs was made. The new photo-microbarograph designed during the previous year was tried and trial records obtained. A new hydrogen purity-gauge was also designed. As a consequence of the discontinuance of manufacture of the vulpro tissue which was being used for making balloons experiments were made with some new varieties of rubber sheeting to test their suitability for the purpose. Test apparatus for the hydraulic test of hydrogen cylinders was installed and is expected to result in convenience as well as in economy.

Comparative observations in Stevenson screens sent by the Air Ministry, London, were completed and a report sent. One candidate was given training and examined in meteorology for the pilot's " B " licence. As in previous years, assistance was given to Professor Mehta of the Agra College for his investigation on the transport of the spores of cereal rust. Classes in meteorology for the Agra University students continued to be held. The usual duties of scrutiny of pilot balloon data and the preparation of pilot balloon data for publication were continued. Cloud observations during the Polar Year period were collected at all pilot balloon observatories and scrutinised. Some observers were trained in following balloons at night. The duties of a first-class observatory and seismological station were also carried on as usual.

Mention of other investigational activities at the observatory has been made under the chief features.

Colaba and Alibag Observatories.—The routine meteorological, seismological, magnetic and time work at Colaba and Alibag Observatories was carried on as usual. These observatories form the departmental centre for geophysical studies. As usual, the observatory maintained a time service for the port of Bombay. The Royal Navy chronometers and watches which had been in stock at the Colaba Observatory for maintenance and rating were transferred to the Colombo Observatory

in May 1933. The Royal Indian Marine continued to stock their chronometers and watches at Colaba, and notwithstanding the transfer of the Royal Navy chronometers, the chronometer transactions during the period remained heavy.

Copies of the Observatory Volume for 1931 were distributed and the volume for 1932 sent to the press. Details of seismograms and magnetograms were sent on several occasions to foreign institutions. Nine seismic radiograms relating to earthquake shocks of moderate or great intensity registered during the period by the Colaba seismographs were sent to the Superintendent, Kew Observatory, London.

The registration of electrical potential gradients was carried on regularly and tables of data prepared for the Polar Year Commission in the form recommended. Other observations in connection with the Polar Year work were continued.

The office supplied meteorological, magnetic, seismic and astronomical information to a large number of civil and military officers including pilots and to members of public institutions. The gestetnered daily weather report giving the summary of the principal features of weather over western India based on the material telephoned from Poona was issued regularly during the period 1st May to 30th November. Unlike previous years the report did not include the bi-weekly crop data.

Alipore Observatory and Meteorological Office, Calcutta.—The principal functions of storm warnings for the Bay of Bengal and heavy rainfall warnings for the surrounding areas and the issue of forecasts to aviators including the regular air mail services on the route between Allahabad and Victoria Point were carried on as satisfactorily as possible. Considerable addition to the work of the office on behalf of aviation took place during the year on account of several new air services passing through Calcutta. The Calcutta Daily Weather Report was issued throughout the year.

The seismological duties of the observatory as well as those of time determination and time signalling were carried on as usual. The meteorological duties of the first-class observatory and pilot balloon station and special observations for the Polar Year continued as in the previous year. The work of testing and standardising the meteorological instruments of the Mathematical Instrument Office, of the Chemical Examiner to the Government of Bengal and of ships' captains was also done as usual.

The collection and examination of logs from ships and the supply of meteorological and other information to the public were attended to satisfactorily. Arrangements were continued with the Indian State Broadcasting Service for broadcasting nor'wester warnings and special weather reports were issued to officers and the public on special occasions.

The issue of weather reports and forecasts for the Ruttledge Expedition continued till the beginning of July 1933. The following telegram received from the leader of the expedition may be quoted: " Expedition ordered home by Everest Committee and leaves base camp July 2nd. Most grateful to you for invaluable help and consistently accurate forecasts. " At the request of Mr. Ruttledge a brief account of Himalayan Meteorology with special reference to the 1933 Everest Expedition was written and sent to the Royal Geographical Society, London, by the Meteorologist.

One second-class Observatory and one voluntary third-class non-reporting Observatory were started during the year. The Squall Report Code was brought into use at second and third-class observatories under this office's control and the Brief Weather Code introduced at the fifth-class stations. 38 observatories were inspected during the year.

Five observatories under this office suffered damage on account of the disastrous earthquake shock on the 15th January. On account of this shock some of the standard clocks in the observatory stopped working. The average rates of the clocks before and after the shock showed differences. The seismographs at Alipore were thrown out of action during the earthquake.

Meteorological Office, Karachi.—This office continued to furnish aviation forecasts on the main air route extending from Bushire on the west to Allahabad on the east and on the air route between Karachi and Ahmedabad. Route forecasts to Royal Air Force flights over Karachi-Jodhpur-Delhi and other air routes were also supplied whenever required.

There was an increase in the work of this office owing to the starting of the Indian Trans-Continental Airways service from Karachi to Singapore. The office continued to supply synoptic and other observational data to the Royal Air Force forecasting centres at Quetta and Peshawar and to the meteorological centre at Hinaidi. The supply of observational data direct from some of the observatories in the Persian Gulf and Mekran to the Meteorologist at Hinaidi was also continued. The total number of surface and upper air observational data so supplied through the Royal Air Force wireless station at Drigh Road during the year was 4,103. The demand for route forecasts for the flights of the Royal Air Force 'planes and squadrons over the forecasting region of this office also showed an increase. Temperature data from aeroplane ascents were obtained on 17 occasions with the assistance of the Air-craft depot, Drigh Road.

As usual, meteorological information was supplied to the public, including officials of the Agricultural Department and Karachi Port, newspapers, Engineers, Municipalities, Railways and so on, while 355 warnings for disturbed weather and anticipated rainfall were issued to various addresses. The Karachi Daily Weather Report continued to be published and well received.

Summaries of weather conditions over the Jodhpur-Rawalpindi Route (*via* Bikaner and Lahore) and the Karachi-~~Allahabad~~ route (*via* Jacobabad and Multan) were supplied to the Indian National Airways, Limited. Meteorological data were also supplied to the Locust Research Entomologist, Karachi, in connection with his locust movement researches under the auspices of the Imperial Council of Agricultural Research.

A scheme for the supply of voluntary reports to the Imperial Airways planes similar to the scheme on the Karachi-Victoria Point route was introduced at Gwador and Bahrein with effect from 1st October 1933 with the co-operation of the Manager, Imperial Airways, Cairo, and the voluntary reports received by land-line from observatories at which there are no wireless stations were also brought into line with the specifications of the new scheme. Pilots of the regular air services visited the office occasionally to study the weather charts. Meteorological logs maintained by pilots were received regularly from the Imperial Airways, I. T. C. A. and the Tata Air Mail Services.

The Karachi Office had 76 observatories under its control and inspected 26 observatories during the year. Three members of the Karachi Aero Club were trained for pilot's "B" licence and a pilot of the Indian Trans-Continental Airways given suitable guidance to prepare for his examination in meteorology for second-class air navigator's licence.

Tabulations of the data for the International Meteorological Committee were continued.

The office continued to be housed in the hired building in the Civil Lines, Karachi. Observatory work was continued at the Drigh Road Observatory.

Kodaikanal Observatory.—The solar and astronomical researches during the calendar year 1933 will be found summarised in the Annual Report of the Kodaikanal Observatory. The routine work of the observatory which has been summarised in previous reports continued to be done satisfactorily. Two staff meetings were held during the year for discussion of scientific topics.

A spectro-helioscope was received on loan from the Mount Wilson Observatory and was being set up. Daily character figures of H_α (dark and bright) flocculi from the photographs of the Kodaikanal Observatory were sent to Professor Brunner of Zurich for incorporation in the bulletin for character figures of solar phenomena. Data of earthquakes and prints of seismograms for the year were sent to the University Observatory, Oxford.

Tabulations of the International Polar Year data were made.

Meteorological Office, Quetta.—This office continued under the charge of an officer seconded from the Indian Meteorological Service but paid by the Royal Air Force. The general inference and forecast of

weather over Sind, Baluchistan and the Punjab continued to be issued by wireless each evening except on Saturdays to the Air Depot, Karachi, and forecasts for the next 24 hours each morning except on holidays to the General Officer Commanding, Western Command, and for the Royal Air Force pilots' notice board. In addition to these route forecasts, special weather reports were supplied to the Royal Air Force whenever required. The forecasts and special weather reports issued during the period numbered 219 and 59 respectively.

Various meteorological data were supplied to the Royal Air Force and other local Government offices. Royal Air Force flying machines continued to take observations of temperatures and pressures in the upper air. During the year, 284 sets of such observations were recorded at Quetta. The daily routine duties of a pilot balloon and first-class observatory and special observations for the International Polar Year were attended to satisfactorily.

Meteorological Office, Peshawar.—This office is in charge of a Royal Air Force Officer who is under the technical, not administrative, control of the Director General of Observatories. Except on Sundays this office issued a weather report and forecast for the North-West Frontier Province, Sind, the Punjab and north Baluchistan area at 8 hours I. S. T. through the Royal Air Force wireless. Heavy rainfall warnings were issued periodically to the Canal Office of the Public Works Department and storm warnings to the Royal Air Force, military and civil authorities.

Forecasts for the Rawalpindi district were also issued daily. 227 route forecasts were issued to Royal Air Force units and 55 *meteor* telegrams supplied to the Artillery Practice Camps. Miscellaneous data and forecasts were supplied to several officers and institutions like the Anti-malaria officer, Police Hospital, etc.

Observations were made of upper air temperatures on 350 days. As a result of the suggestion by the Meteorological Officer the measurements of upper air temperatures up to 16,000 ft. above ground level at Peshawar, Kohat and Risalpur and up to 11,000 ft. above ground level at Quetta have been agreed to by the Royal Air Force. On several occasions arrangements were made to supply machines in flight with hourly values of upper wind speed and direction.

Some of the investigations undertaken by the Meteorological Officer have been mentioned under the Chief Features. In addition a note on vertical winds over the northwest frontier was prepared for Mr. J. H. Field; a note on the mean monthly variation of air density in the North-West Frontier Province was supplied to the Royal Air Force units, an investigation of the cold spell in January and of other similar cold spells was taken up, an investigation of turbulence during dust-storms was begun and an analysis of rainfall at Peshawar and Cherat was made.

Other Observatories.—The numbers of observatories of various classes are shown in the table below, which also gives the corresponding figures at the end of the previous year. For a description of classification of these observatories, the reader is referred to Appendix C.

	On 31st March 1934.	On 31st March 1933.
I Class	15	15
II Class	166	163
III Class	86	86
IV Class	22	22
V Class	24	24
Non-instrumental	15	7
Total* . . .	328	317
Non-departmental	61	61

*This total includes the non-departmental observatories whose number is shown separately in the next row.

The records of the non-departmental observatories were scrutinised by this department and in most cases utilised in the daily weather reports and other departmental publications. The importance of these observatories need hardly be emphasised and the co-operation of the Indian States and other public bodies, who maintained them for the furtherance of the study of Indian meterology, is much appreciated. Among these may be mentioned the Kingdom of Nepal and the States of Bahawalpur, Baroda, Bhopal, Bikaner, Cooch Behar, Hyderabad, Ichalkaranji, Jaipur, Jhalawar, Kashmir, Miraj, Mysore, Nawanagar, Patiala and Travancore, the municipalities of Ahmedabad, Coonoor, Murree and Mussooree and the Agricultural Departments of Bombay and the Punjab.

Rainfall Registration.

The rainfall data collected by the provincial rainfall organisations, for which the Director-General of Observatories is the consulting authority, are published in the provincial rainfall tables, which are collected and issued in a single volume for the whole of India by this department. The number of stations included in the organisation in the different provinces and the number inspected during the year, together with corresponding figures for the previous year, are given in the following table. On the whole the work of rainfall registration was carried out satisfactorily throughout India.

Rainfall Registration during 1933-34.

No.	Province.	No. of raingauges at the end of			No. of raingauges inspected.			Remarks regarding the condition of raingauges.
		1933-34.	1932-33.	Changes.	1933-34.	1932-33.	Changes.	
1	Burma . . .	215	215	0	214	211	+3	Satisfactory.
2	Assam . . .	128	128	0	111	109	+2	Do.
3	Bengal . . .	235	235	0	187	194	—7	Do.
4	Bihar and Orissa (*a*) .	276	274	+2	259	254	+5	Do.
5	United Provinces .	269	269	0	265	259	+6	Do.
6	Punjab . . .	196	195	+1	121	157	—36	Do.
7	Jammu and Kashmir.	30	31	—1	13	10	+3	Do.
8	N.-W. F. Province .	30	30	0	24	25	—1	Do.
9	Baluchistan . .	73	72	+1	69	51	+18	Do.
10	Bombay (*c*) . .	262	261	+1	215	231	—16	Do.
11	States in Bombay Presidency.	72	69	+3	37	...	...	Do.
12	Rajputana . .	184	183	+1	165	163	+2	Do.
13	Central India . .	122	121	+1	103	98	+5	Do.
14	Central Provinces (*b*).	167	172	—5	165	154	+11	Do.
15	Berar . . .	42	42	0	42	42	0	Do.
16	Eastern States . .	46	44	+2	41(*d*)	39(*d*)	+2(*d*)	Do.
17	Hyderabad . .	53	53	0	0	0	0	Do.
18	Mysore . . .	75	75	0	75	75	0	Do.
19	Coorg . . .	20	9	+11	18	7	+11	Do.
20	Madras . . .	513	512	+1	478	485	—7	Do.

(*a*) Excluding stations in Indian States (transferred to the Eastern States Agency).
(*b*) " " " " " (transferred to the Eastern States Agency and to Bhopal).
(*c*) " " " " "
(*d*) Information regarding 4 raingauges not available.

Heavy Rainfall Reports.—Heavy rainfall is sometimes so very local that small unrepresented areas can have as much as 10 inches without the present net-work of daily reporting stations conveying the least suggestion of the local deluge. To obtain reports of such local heavy rain promptly for the daily weather report, it was arranged 12 years ago that observers at the provincial raingauge stations should telegraph to forecasting centres falls of 5 inches or more. The number of such telegrams received during 1933-34 was 318 as compared with 279 in the previous year.

Snowfall Registration.—Information about the distribution and the time of occurrence of snowfall in the Himalayas and the Afghan mountain areas was on the whole tolerably complete and the thanks of the department are due to the various officers who collected and forwarded the reports.

Concluding Remarks.

The Meteorological Department owes a large part of its usefulness to the sympathetic assistance it receives from other departments. Officers of various Government departments help the meteorological work as Honorary Superintendents of Observatories or in other capacities. The Posts and Telegraphs Department assists this department in the rapid transmission of meteorological information particularly in connection with the warning services.

Weekly telegrams are received from April to October from the Director, Royal Alfred Observatory, Mauritius. These telegrams give valuable information of the weather conditions in the Indian Ocean, and the department is indebted to this observatory for the punctual transmission of the information.

The department is greatly indebted for important information on meteorological conditions prevailing before and during the southwest monsoon to the Controller, Physical Department, Cairo ; the Directors of the Observatories at Buenos Ayres and Santiago ; the Astronomer Royal Cape Town ; Director L'Observatorie Physique Central, Leningrad ; the Secretary, Friends' Industrial Mission, Banani Pemba, Zanzibar ; the Director, Department of Agriculture, Zanzibar ; the Director, British East African Meteorological Service ; the Port Officer, Seychelles ; the Commonwealth Meteorologist, Melbourne ; Director of Agriculture, Salisbury, Rhodesia ; Chief of the Weather Bureau, Washington. Thanks are due to the Director, Koninklijk Magnetisch und Meteorologisch Observatorium, Batavia, for similar information and also for the daily weather telegrams from Sabang in Sumatra during the cyclone months April, May and October to December.

Thanks are due to the Marine Superintendents of the British India Steam Navigation Company, the Scindia Steam Navigation Company, the Asiatic Steam Navigation Company, and the Burma Oil Company for continuing the arrangement under which many captains of their fleets send weather logs to this Department. The Principal Officer, Mercantile Marine Department, Bombay, the Deputy Conservator of

the Port of Bombay, the Deputy Conservator of the Port of Calcutta and the Flag Officer Commanding and Director, Royal Indian Marine, have been willing helpers of this department, for which it is grateful to them.

The department is indebted to the Government of His Exalted Highness the Nizam of Hyderabad and to the Government of His Highness the Maharaja of Mysore for their co-operation by regular collection of pilot balloon data at the Nizamiah Observatory, Begumpet (Hyderabad), and the Central Observatory, Bangalore, respectively, as also for their assistance in the recovery of sounding balloon instruments found in their territories. The Department is also grateful to the Government of Travancore for their co-operation by regular collection of pilot balloon data at Trivandrum.

The department thanks the Directors of Agricultural Departments and Institutions in the different provinces and the various agricultural research workers in the country for their valuable co-operation with the Branch of Agricultural Meteorology. It is also indebted to the Director of Agriculture, Bombay Presidency, and the Principal of the Agricultural College, Poona, for kindly providing the space and facilities for that branch to conduct its experimental work.

Thanks are due to the Eastern Telegraph Company for charging this Department half the usual rates for the transmission of South American Weather telegrams. Thanks are also due to the various pilots of the Imperial and Indian Trans-Continental Airways, Tata Sons, Limited, and to the Dutch and French Air Services for the supply of weather logs to this department; to the various ships' officers, who send their marine weather logs direct to this Department; to the Superintendent of the Colombo Observatory for the most useful help he has rendered from time to time in connection with storm warning work and for the useful data of Ceylon stations supplied to this Department.

POONA;
The 30th June 1934.

C. W. B. NORMAND,
Director-General of Observatories.

APPENDIX A.

THE STAFF OF THE INDIA METEOROLOGICAL DEPARTMENT AS IT STOOD ON 31ST MARCH 1934.

METEOROLOGICAL OFFICE, POONA.

Director-General of Observatories.

C. W. B. Normand, M.A., D.Sc. (Edin.).

General Section.

Meteorologist	V. V. Sohoni, B.A. (Hons.), M.Sc. (Bombay).
Assistant Meteorologist	B. N. Sreenivasaiah, M.Sc. (Cal.).
Superintendent	C. P. Venkataramier, M.A. (Madras).
Assistants	5.
Stenographers	4.
Cashier	1.
Clerks and Typists	11.

Weather Section.

Meteorologist	S. Basu, M.Sc. (Allahabad).
Assistant Meteorologist	B. N. Desai, M.Sc. (Bombay), Ph.D. (Edin.), B.A., LL.B., Bombay.
Assistants	2.
Clerks and Tabulators	12.
Draftsmen	5.

Observatories Section.

Assistant Meteorologist	Barkat Ali, B.A., M.Sc. (Punjab).
Assistants	2.
Inspector of Observatories	1.
Clerks	2.
Junior Observers	8. (at outstations).

Marine Section.

Meteorologist	K. J. Kabraji, B.A. (Hons.), B.Sc. (Bombay), M.Sc., Ph.D. (London).
Assistant	1.
Clerks	2.

Instruments Section.

Meteorologist	J. M. Sil, B.A. (Cal.), B.Sc. (Engg.) (Boston Tech.).
Assistant Meteorologist	S. Mal, M.Sc., Ph.D., D.I.C. (London).
Assistants	2.
Clerks	5.
Draftsman	1.
Senior Observers	3.
Junior Observer	1.
Storekeeper	1.
Mechanics (temporary)	2.

Upper Air Section.

Meteorologist	K. R. Ramanathan, M.A., D.Sc. (Madras).
Assistant Meteorologist	S. L. Malurkar, B.Sc. (Mysore), M.Sc. (Cantab.).
Assistant	1.
Clerks	2.
Senior Observer	1.
Junior Observers	4.

Library Section.

(Including Climatology Branch.)

Meteorologist	S. R. Savur, M.A. (Madras), Ph.D. (London).
Assistant Meteorologist	V. Doraiswamy Iyer, B.A. (Madras.)
Assistants	3.
Librarian	1.
Clerks	15.
Draftsmen	3.

Agricultural Meteorology Branch.

Junior Agricultural Meteorologist	L. A. Ramdas, M.A., Ph.D. (Calcutta.)
Professional Assistant	R. J. Kalamkar, B.Sc. (Nagpur), B.Ag. (Nagpur), Ph.D. (London).
Senior Observers	2.
Junior Computors	3.

Upper Air Observatory, Agra.

Meteorologist-in-charge	G. Chatterjee, M.Sc. (Calcutta).
Meteorologist	N. K. Sur, D.Sc. (Allahabad).
Assistant Meteorologists	K. Das, M.Sc. (Punjab), Ph.D. (London). S. P. Venkiteshwaran, B.A. (Hons.) (Madras) (temporary). S. K. Das, M.Sc. (Dacca & London), D.I.C. (*Offg.*).

UPPER AIR OBSERVATORY, AGRA—*contd.*

Superintendent	Babu Ram Samnol.
Mechanical Assistant	Chain Sukh.
Chief Observer	1.
Chief Computor	1.
Foreman	1.
Clerks or Observers (Permanent)	41 (at Agra).
Clerks or Observers (Permanent)	68 (out-station staff).
Mechanics (temporary)	10.
Clerks and Observers (temporary)	9.
Enginemen (permanent)	2.

COLABA AND ALIBAG OBSERVATORIES, BOMBAY.

Meteorologist	S. C. Roy, M.Sc. (Cal.), D.Sc. (London).

At Colaba.

Head Clerk	D. L. Choudhuri, M.Sc. (Cal.) (on probation).
First Assistant	1.
Observers	6.
Cashier	1.
Marine Clerk	1.
Typist and Stenographer	1.

At Alibag.

Observers	2.

ALIPORE OBSERVATORY AND METEOROLOGICAL OFFICE, CALCUTTA.

Meteorologist	S. N. Sen, M.Sc. (Cal. and London), Ph.D. (London).
Assistant Meteorologists	A. K. Das, M.Sc. (Cal.), D.Sc. (Paris). S. S. Lal, M.Sc. (Lucknow & London), D.I.C. (London) (temporary). C. Ramaswamy, M.A. (Hons.) (Madras) (*Offg.*).
Professional Assistant	N. P. Chatterji, M.Sc. (Cal.).
Superintendent	T. N. Mitra, B.A., B.L.
Chief Observer	B. B. Roy, M.Sc. (on probation).
Meteorological Assistants	3. (On Poona Establishment posted at auxiliary centres).
Inspector of Observatories	1.
Clerks (Upper division)	4.
Stenographer	1.
Senior Observers	2.

ALIPORE OBSERVATORY AND METEOROLOGICAL OFFICE, CALCUTTA—*contd.*

Clerks and Observers (Lower division)	22.
Clerks (Routine division)	5.
Junior Observers	2.
Observers (at out-stations)	5.
Printer (Press staff)	1.

METEOROLOGICAL OFFICE, KARACHI.

Meteorologist	S. K. Pramanik, M.Sc. (Lucknow), Ph.D., D.I.C. (London).
Assistant Meteorologists	P. R. Krishna Rao, B.Sc. (Mysore). B. K. Roy, M.Sc.(Calcutta) (on leave). H. R. Puri, M.Sc. (Punjab) (*Offg.*).
Professional Assistant	*H. R. Puri, M.Sc. (Punjab). (Offg. as Assistant Meteorologist).*
Meteorological Assistant	1. (On Poona Establishment, posted at auxiliary centre at Jodhpur).
Chief Observer	1.
Head Clerk	1.
Inspector of Observatories	1.
Stenographer	1.
Senior Clerks or Observers	4.
Clerks or Observers	9.
Clerks	5.
Junior Clerks or Observers	2.
Observers (at out-stations)	3.

SOLAR PHYSICS OBSERVATORY, KODAIKANAL.

Director	T. Royds, D.Sc. (London).
Assistant Director	A. L. Narayan, M.A., D.Sc. (Madras), F.I.P.
Assistants	3.
Recorders	4.
Mechanic	1.
Book-binders	2 (1 post vacant).

METEOROLOGICAL OFFICE, No. 3 (INDIAN) WING, R. A. F., QUETTA.

Meteorologist	A. K. Roy, B.Sc. (Cal.), B.A. (Oxon.) (temporary).
Senior Clerk	1.
Junior Clerks	3.

METEOROLOGICAL OFFICE, No. 1 (INDIAN) GROUP HEADQUARTERS, R. A. F., PESHAWAR.

Meteorological Officer (R. A. F.)	F./Lt. R. G. Veryard, B.Sc.
Senior Clerk	1.
Junior Clerks and Observers	3.

LAHORE OBSERVATORY.

Chief Observer	1.
Observer	1.

MADRAS OBSERVATORY.

Assistant-in-charge	1.
Senior Observer	1.
Junior Observers	2.

OFFICERS ON LEAVE.

S. K. Banerji, M.Sc., D.Sc. (Cal.).
B. N. Banerji, M.Sc. (Allahabad), Ph.D. (Cantab.).
B. K. Roy, M.Sc. (Cal.).

APPENDIX B.

PUBLICATIONS.

The following departmental publications were issued or sent to press during the year :—

I.—*Periodical.*

1. Daily Weather Reports :—
   i. Indian Daily Weather Report.
   ii. Calcutta Daily Weather Report.
   iii. Karachi Daily Weather Report.
2. Weekly Weather Report.
3. India Weather Review, Monthly Weather Report.
4. India Weather Review, Annual Summary for 1932, in seven parts :—
   i. Introduction.
   ii. Part A.—Summary of Weather and Rainfall.
   iii. Part B.—Snowfall.
   iv. Part C.—Storms and Depressions.
   v. Part D.—Annual Tables.
   vi. Part E.—Seismic Records.
   vii. Part F.—Errata to Monthly Weather Reports.
5. Daily Rainfall of India for 1931.
6. Monthly Rainfall of India for 1931.
7. Upper Air Data, 1932, in 14 parts :—
   i. Parts 1—12.—Pilot Balloon and Aeroplane Data for January to December.
   ii. Part 13.—Monthly Means of Pilot Balloon Data and Monthly Frequencies of Clouds.
   iii. Part 14.—Sounding Balloon Data.
8. Seasonal Memoranda :—
   i. Memorandum on the probable character of the weather in North-West India in January, February and March 1934.
   ii. Statement of the rainfall and snowfall of North-West India in January, February and March 1933 and a comparison of the seasonal forecast with the actual precipitation.
   iii. Memorandum regarding the probable amount of monsoon rainfall in 1933.
   iv. Memorandum on the rainfall of June and July and the probable amount during August and September 1933.
   v. Statement of the actual rainfall in the monsoon season, June to September 1933, and a comparison of the forecasts with the actual rainfall.
9. Magnetic, Meteorological and Seismographic Observations made at the Government Observatories, Bombay and Alibag, in the year 1931.
10. Report on the Administration of the Meteorological Department of the Government of India in 1932-33.
11. Annual Report of the Kodaikanal Observatory, 1933.

II.—*Occasional.*

1. Memoirs of the India Meteorological Department :—

Vol. XXVI—

Part III.—On the Physical Characteristics of Fronts during the Indian Southwest Monsoon, by N. K. Sur.

Part IV.—Discussion of Results of Sounding Balloon Ascents at Poona and Hyderabad during the period October 1928 to December 1931, by K. R. Ramanathan, M.A., D.Sc., and K. P. Ramakrishnan, B.A.

2. Scientific Notes :—

Vol. V—

No. 55.—On the Nature of the Frequency Distribution of Precipitation in India during the Monsoon months June to September, by D. Sankaranarayanan.

No. 56.—A Preliminary Study of a Tornado at Peshawar, by Flt. Lieut. R. G. Veryard, B.Sc., R.A.F.

No. 57.—Humidity Records obtained at Agra with Hair Elements and with Wet and Dry Elements in a Dines' Meteorograph, by S. P. Venkiteshwaran.

No. 58.—On Forecasting Weather over Northeast Baluchistan during the Monsoon Months July and August, by A. K. Roy, B.A., B.Sc., and R. C. Bhattacharya, M.Sc.

No. 59.—A Statistical Study of the Maximum Temperatures at Poona, by R. J. Kalamkar, B.Sc., B.Ag., Ph.D.

3. Kodaikanal Observatory Bulletins :—

No. CI.—The Hydrogen Content of Prominences, by C. P. S. Menon B.A., M.Sc., F.R.A.S.

No. CII.—Summary of Prominence Observations for the Second Half of the Year 1932.

No. CIII.—Summary of Prominence Observations for the First Half of the Year 1933.

4. Meteorological Conditions affecting Aviation over the North-West Frontier by Flt. Lt. R. G. Veryard, B.Sc., R.A.F. and A. K. Roy, B.A., B.Sc.

The following papers or notes were contributed by members of the staff to extra-departmental journals :—

Banerji, S. K.—

The South Indian Cyclone of December 13-16, 1933,—Current Science Vol. II, 1934, pp. 335—338.

—— North Bihar Earthquake of January 15, 1934,—Current Science, Vol. II, 1934, pp. 326—331.

—— and Manohar, M. D.—

On the Artificial Vibrations of Ground,—Indian Journal of Physics, Vol. VIII, 1933, pp. 95—121.

Sohoni, V. V.—

Weather Types associated with Nor'westers in Bengal,—Journal and Proceedings of the Asiatic Society of Bengal, Vol. 28 (1932), 1933, pp. 349—358.

—— and Miss Paranjpe, M. M.—

Fog and Relative Humidity in India,—Q. J. Roy. Met. Society, Vol. 60, 1934, pp. 15—21.

Ramanathan, K. R.—

Some exceptionally high sounding-balloon ascents at Poona and temperatures in the stratosphere over the tropics,—Current Science, Vol. II, 1933, p. 178.

—— and Karandikar, J. V.—

Spectrum of the Night Sky and of the Zodiacal light,—Nature, Vol. 132, 1933, p. 749.

—— and Ramakrishnan, K. P.—

Distortion of the Tropopause due to Meridional Movements in the Substratosphere,—Nature, Vol. 132, 1933, p. 982.

Roy, S. C.—

Focal Region of the North Bihar Earthquake of January 15, 1934,—Current Science, Vol. II, 1934, pp. 419—422.

Unakar, M. V.—

Meteorology in the Rig-Veda,—Journal of the Bombay Branch, Royal Asiatic Society, Vol. 9, 1933, pp. 53—78.

Barkat Ali—

High lapse-rates of temperature and their diurnal variation in the surface layers of the atmosphere over Northern India—Gerlands Beiträge zur Geophysik, Band 39, 1933, pp. 121—140.

Desai, B. N.—

Influence of Wall effect on the nature of the coagulation process,—Current Science, Vol. 1, 1933, p. 376.

—— and Basu, S.—

Evidence in favour of non-symmetrical structure in the inner storm area of cyclones in the Indian Seas,—Gerlands Beiträge zur Geophysik, Band 40, 1933, p. 1.

—— and Mal, S.—

Vertical structure of the surface of discontinuity between the continental and the monsoon air-masses in the premonsoon period,—Gerlands Beiträge zur Geophysik, Band 40, 1933, p. 12.

—— and Baskar, S. K.—

Importance of dialysis in the study of Colloids, Part I, Colloidal ferric hydroxide,—Transactions of the Faraday Society, Vol. 29, 1933, p. 1269.

—— and Desai, A. K.—

Importance of dialysis in the study of Colloids, Part II, Colloidal thorium hydroxide—Transactions of the Faraday Society, Vol. 30, 1934, p. 265.

——, Desai, H. N., Naik, D. B., and —

Negative viscosity of solutions,—Current Science, Vol. 2, 1933, p. 206.

—— Naik, B. M., Desai, H. N., and—

Condition of silver chromate, silver iodide and lead iodide in gelatine, —Journal of the Indian Chemical Society, Vol. 11, 1934, p. 45.

——and Naik, B. M.—

Influence of acidity of gelatine on the Liesegang rings of silver chromate and silver iodide,—Journal of the Indian Chemical Society, Vol. 11, 1934, p. 59.

Das, A. K.—

On the mechanism of thundersqualls in Bengal,—Gerlands Beiträge zur Geophysik, Band 39, 1933, pp. 144—166.

A suggestion as to the origin of tornadoes in Bengal,—Current Science, Vol. I, 1933, pp. 386—388.

On the Temperature of Rain,—Meteorological Magazine, Vol. 68, 1933, pp. 209—210.

APPENDIX C.

Classification of Observatories, etc.

Meteorological or Weather Observatories.—The functions of a meteorological or weather observatory are to record the observations of such elements as can be recorded by an observer with the help of instruments on the ground (as distinct from upper air observations obtained by means of balloons, etc.). Observatories where the staff is provided and paid for by other agencies, *e.g.*, Indian States are called non-departmental although instruments are supplied by the Meteorological Department. These surface observatories are classified according to the number of observations per day and the number and kind of instruments to be read. Thus :

First Class.—Such observatories are furnished with autographic instruments for continuously recording pressure, temperature, humidity, wind direction and velocity, and rainfall, in addition to instruments, read by eye. These may also undertake special observations (*e.g.*, on atmospheric electricity). The staff required varies from two part-time observers to about four full-time observers according to the amount of special work and of computation and tabulation of data.

Second Class.—At second class observatories observations are taken twice daily and usually telegraphed to one or more forecast centres. The existing standard times of observation in India are 8 hrs. (Local Time) and 17 hrs. (Indian Standard Time), the observations being made by a part-time observer on Rs. 25 per mensem. At certain II class observatories, practically all of which are non-departmental, observations are recorded twice daily, at 10 and 16 hrs. (Local Time) but not telegraphed.

Third Class.—At these observatories readings are taken daily at 8 hrs. and sent by telegram daily or by post at the end of each month to one or more forecast centres. At each observatory of this type there is one part-time observer on Rs. 15 a month.

Fourth Class.—Observations of (*a*) of temperature, wind and rainfall only or (*b*) of temperature and rainfall only are recorded at IV class observatories. At each observatory of this type there is one part-time observer on pay not exceeding Rs. 12 a month.

Fifth Class Weather Observatories.—At these observatories part-time observers on Rs. 5 p.m. record and telegraph rainfall only.

Non-Instrumental Observatories.—Observatories which do not possess any instruments but at which visual observations of *clouds, visibility,* approximate wind direction and force and weather phenomena are recorded by an observer and reported to a forecasting centre either by post or by daily telegrams. Some of these observatories are non-departmental and some have been established for reporting "Current Weather" to aviators.

Pilot Balloon Observatories.—At such observatories pilot balloons (*i.e.*, balloons without attached instruments) are released and observed through special theodolites for the determination of wind directions and velocities at various heights in the free atmosphere. The minimum staff is two full-time observers for one balloon flight per day and 3 full-time observers and a balloon maker for two balloon flights per day.

Upper Air Observatories.—Upper Air Observatories undertake in addition to observations of upper winds, those of upper air temperatures, humidities and pressures up to heights of about 15-20 miles by means of sounding balloons (*i.e.*, balloons with self-recording instruments attached).

Air Observatories.—Air Observatories are those to which Royal Air Force supply aeroplane data of temperatures and humidities up to heights of 2 or 3 miles.

Magnetic Observatory.—An observatory of this type is equipped with instruments for continuously recording the principal magnetic elements.

Seismological Stations.—Such stations are equipped with one or more continuously recording seismographs.

Time Observatories.—These are equipped with instruments for the determination of time from transit observations of sun and stars and from European wireless time signals.

Solar Physics Observatory.—The Department has an observatory at Kodaikanal equipped with photoheliograph, spectroheliograph, etc., where special work on solar physics is done.

Auxiliary Centre.—A centre where a Professional or Meteorological Assistant receives copies of weather reports from the forecasting centres for transmission to pilots.

Forecast Centre.—These centres are located at different meteorological offices such as Calcutta, Karachi, etc., where weather observations are collected by telegram from a number of stations in order to form the basis of weather reports and forecasts issued therefrom. These may be (*a*) Main Centres, serving a large area for general purposes, *e.g.*, the H. Q. office at Poona or (*b*) Regional Centres, serving more limited areas for special purposes, for instance, air-routes.

GIPD—M82 Dd of Obs. Poona—17-9-34—480.

NO—RM/35.

15 NOV. 1935

LIBRARY OF THE BOMBAY BRANCH OF THE ASIATIC SOCIETY

Report on the Administration of the Meteorological Department of the Government of India in 1934-35.

PUBLISHED BY MANAGER OF PUBLICATIONS, DELHI.
PRINTED BY THE MANAGER, GOVERNMENT OF INDIA PRESS, NEW DELHI.
1935.

List of Agents in India from whom Government of India Publications are available.

(a) PROVINCIAL GOVERNMENT BOOK DEPOTS.

MADRAS :—Superintendent, Government Press, Mount Road, Madras.

BOMBAY :—Superintendent, Government Printing and Stationery, Queen's Road, Bombay.

SIND :—Library attached to the Office of the Commissioner in Sind, Karachi.

UNITED PROVINCES :—Superintendent, Government Press, Allahabad.

PUNJAB :—Superintendent, Government Printing, Punjab, Lahore.

BURMA :—Superintendent, Government Printing, Burma, Rangoon.

CENTRAL PROVINCES :—Superintendent, Government Printing, Central Provinces, Nagpur.

ASSAM :—Superintendent, Assam Secretariat Press, Shillong.

BIHAR AND ORISSA :—Superintendent, Government Printing, P. O. Gulzarbagh, Patna.

NORTH-WEST FRONTIER PROVINCE :—Manager, Government Printing and Stationery, Peshawar.

(b) PRIVATE BOOK-SELLERS.

Advani Brothers, P. O. Box 100, Cawnpore.
Aero Stores, Karachi.*
Albert Library, Dacca.
Banerjee & Bros., Ranchi, Messrs. G.
Banthiya & Co., Ltd., Kucheri Road, Ajmer.
Bengal Flying Club, Dum Dum Cantt.*
Bhawnani & Sons, New Delhi.
Book Company, Calcutta.
Booklover's Resort, Taikad, Trivandrum, South India.
Burma Book Club, Ltd. Rangoon.
Butterworth & Co., (India), Ltd., Calcutta.
Calcutta Book Agency, 16-1, Shama Charan De Street, Calcutta.
Chatterjee & Co., 3, Bacharam Chatterjee Lane, Calcutta.
Chukervertty, Chatterjee & Co., Ltd., 13, College Square, Calcutta.
City Book Co., Madras.
City Book House, Meston Road, Cawnpore.
Commercial Book Co., Lahore.
Das Gupta & Co., 54/3, College Street, Calcutta.
Deccan Book Stall, Poona 4.
Delhi and U. P. Flying Club, Ltd., Delhi.*
English Book Depot, Ferozepore.
English Book Depot, Taj Road, Agra, and Saddar Bazar, Jhansi.
English Book Depot, Bank Road, Ambala Cantt. and Kasauli.
English Bookstall, Karachi.
Faqir Chand Marwah, Peshawar Cantt.
Fono Book Agency, Simla.
Gaya Prasad & Sons, Agra.
Grantha Mandir, Cuttack.
Higginbothams, Madras.
Hindu Library, 137/F, Balaram De Street, Calcutta.
Hyderabad Book Depot, Chaderghat, Hyderabad (Deccan).
Imperial Book Depot and Press, near Jama Masjid (Machhliwalan), Delhi.
Indian Army Book Depot, Dayalbagh, Agra.
Indian Army Book Depot, Jullundur City and Daryaganj, Delhi.
Indian Book Shop, Benares City.
Indian School Supply Depot, 309, Bow Bazar St., Calcutta.
Insurance Publicity Co., Ltd., Lahore.
International Book Service, Poona 4.
Jacques & Co., Kamptee Road, Nagpur, Messrs. Neston.
Jaina & Bros., Mori Gate, Delhi, and Connaught Place, New Delhi, Messrs. J. M.
James Murray & Co., 12, Govt. Place, Calcutta (for Meteorological publications only).
Kali Charan & Co., Municipal Market, Calcutta.
Kamala Book Depot, 15, College Square, Calcutta.
Kamala Book Stores, Bankipore, Patna.
Karnataka Publishing House, Bangalore City.
Kenle & Co., Karachi.
Kitabistan, 17-A, City Road, Allahabad.
Krishnaswami & Co., Teppakulam P. O., Trichinopoly Fort, Messrs. S.
Lahiri & Co., Calcutta, Messrs. S. K.
Law Printing House, 11, Mount Road, Madras.
Law Publishing Co., Mylapore, Madras.
Lawrence and Mayo, Ltd., Bombay (for Meteorological publications only).
Local Self-Govt. Institute, Bombay.
London Book Co. (India), Arbab Road, Peshawar, Murree, Nowshera, Rawalpindi.
London Book Depot, B. I. Bazar, Bareily, U. P.
Malhotra & Co., Quetta, Messrs. U. P.
Mohanlal Dossabhai Shah, Rajkot.
Nandkishore & Bros., Chowk, Benares City.
Nateson & Co., Publishers, George Town, Madras, Messrs. G. A.
New Book Co., "Kitab Mahal," 192, Hornby Road, Bombay.
Newman & Co., Ltd., Calcutta, Messrs. W.
North India Christian Tract and Book Society, 18, Clive Road, Allahabad.
Oriental Book Supplying Agency, 15, Shukrawar, Poona City.
Oxford Book and Stationery Company, Delhi, Lahore, Simla, Meerut and Calcutta.
Parikh & Co., Baroda, Messrs. B.
Pioneer Book Supply Co., 20, Shib Narayan Das Lane, Calcutta and 219, Cloth Market, Delhi.
Popular Book Depot, Grant Road, Bombay.
Punjab Religious Book Society, Lahore.
Punjab Sanskrit Book Depot, Saidmitha Street, Lahore.
Raghunath Prasad & Sons, Patna City.
Rama Krishna & Sons, Booksellers, Anarkali, Lahore.
Ram Krishna Bros., Opposite Bishrambag, Poona City.
Ram Narain Lal, Katra, Allahabad.
Ramesh Book Depot & Stationery Mart, Kashmere Gate, Delhi.
Ray & Sons, 43, K. & L. Edwardes Road, Rawalpindi, Murree and Peshawar, Messrs. J.
Ray Chowdhury & Co., 68/5, Ashutosh Mukherjee Road, Calcutta.
Rochouse & Sons, Madras.
Roy Chowdhury & Co., 11, College Square, Calcutta, Messrs. N. M.
Sampson William & Co., 127-B, The Mall, Cawnpur
Sarcar & Sons, 15, College Square, Calcutta, Messrs. M. C.
Sarkar & Co., Ltd., 18, Shama Charan De Street, and 8/2, Hastings Street, Calcutta, Messrs. P. C.
Scientific Publishing Co., 9, Taltola Lane, Calcutta.
Seshachalam & Co., Masulipatam, Messrs. M.
Shivji & Co., P. O. Chauliaganj, Cuttack.
Shri Shankar Karnataka Pustaka Bhandara, Malamuddi, Dharwar.
S. P. Bookstall, 21, Budhwar, Poona.
Standard Bookstall, Karachi.
Standard Bookstall, Quetta.
Standard Book Depot, Lahore, Dalhousie and Delhi.
Standard Law Book Society, 5, Hastings Street, Calcutta.
Standard Literature Company, Ltd., Calcutta.
Students' Popular Depot, Kacheri Road, Lahore.
Surat and District Trading Society, Surat.
Taraporevala Sons & Co., Bombay, Messrs. D. B.
Thacker & Co., Ltd., Bombay.
Thacker, Spink & Co., Ltd., Calcutta and Simla.
Tripathi & Co., Booksellers, Princes Street, Kalbadevi Road, Bombay, Messrs. N. M.
Union Stores, Indore City.
University Book Agency, Kacheri Road, Lahore.
Upper India Publishing House, Ltd., Literature Palace, Ammuddaula Park, Lucknow.
Varadachary & Co., Madras, Messrs. P.
Wheeler & Co., Allahabad, Calcutta and Bombay, Messrs. A. H.
Young Man & Co., Ajmer, and Egerton Road, Delhi.

* Agent for publications on Aviation only.

28 / 1935

Report on the Administration of the Meteorological Department of the Government of India in 1934-35.

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Plate—Frost at Nasik (see also page 15)	Frontispiece

FROST AT NASIK.

FIG. 1.

FIG. 2.

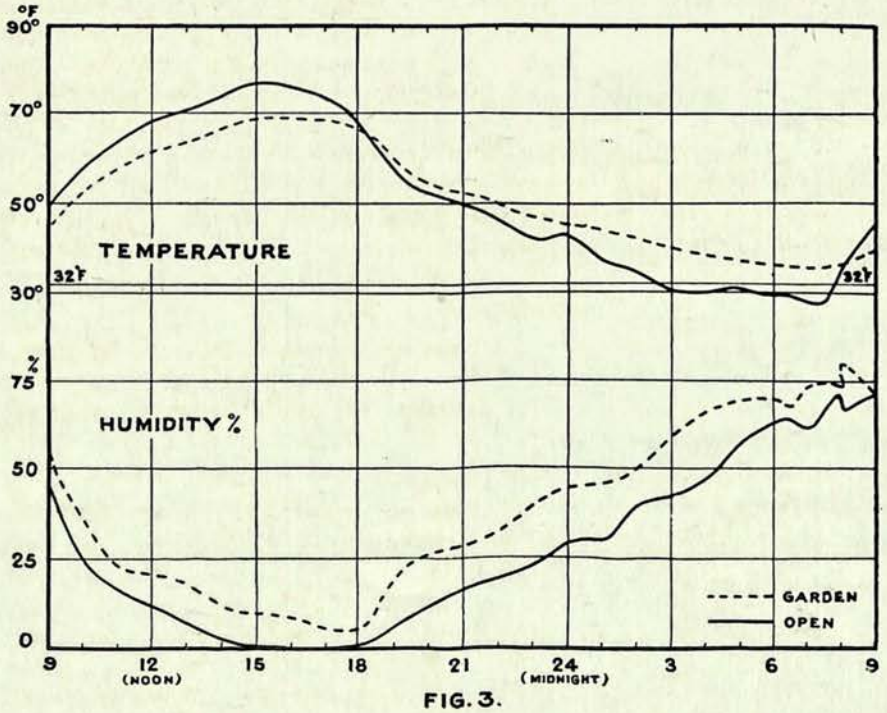

FIG. 3.

Figures 1 and 2 represent a healthy vine and a vine affected by frost respectively at Nasik during a cold wave in January 1935.

Figure 3 shows the hourly variation of temperature and percentage humidity of the air inside a vine garden and in a neighbouring open space at Nasik, from 9 a.m. on 15-1-1935 to 9 a.m. on 16-1-1935 when the cold wave was most intense. The straight line in the upper diagram represents 32° F. or the freezing point of water. The air temperature was below freezing point for nearly five hours on the 16th morning. Air inside the garden was cooler during day and warmer during night, and generally more humid than that in the open.

Report on the Administration of the Meteorological Department of the Government of India in 1934-35.

Chief Features of the year.

The meteorological arrangements on the main trans-India air-route were reorganised in order to serve the greatly increased air traffic without appreciable increase in staff or budget. In previous years it had been the practice to issue a separate forecast to each aircraft in respect of the route covered by it each day from the forecasting centre concerned. As air services were increasing and duplicated weekly services were expected from the year 1935, it was considered that it would soon become impossible for the two forecasting centres at Karachi and Calcutta to serve each aeroplane individually on the 4000-mile route from Bahrein to Victoria Point. Arrangements were, therefore, made to broadcast forecasts in respect of each section of the route at fixed times as a regular routine. With the co-operation of the Director of Wireless and the Director of Civil Aviation in India, the new arrangement was brought into force from 1st October 1934. Under this scheme a forecast for the next 24 hours is issued each evening for each section of the route and distributed by wireless to the aerodromes concerned. The main evening forecast is supplemented or amended if necessary at noon each day and these messages are also distributed in the same way by wireless. The dissemination of the latest upper wind data through wireless, twice daily, from pilot balloon stations along the trans-India air route was also placed on a similar routine basis. For transmission along the wireless chain the pilot balloon stations also provide data about heights of base of low clouds whenever the cloud base is below a certain height or whenever an air-craft makes a special request. These reports and forecasts are also exhibited on Weather Notice Boards at the principal aerodromes on the Karachi-Victoria Point route.

For the Karachi-Lahore Air Service inaugurated during the year, a new pilot balloon station was opened at Sukkur and arrangements were also made to take two pilot balloon observations every day at Lahore, instead of one, as hitherto.

The capital expenditure scheme for the development of air-routes in India will help to make the meteorological service more efficient. It will allow the forecasting centre at Karachi to be housed on the aerodrome and aid personal contact between pilots and forecasting officers. New offices, observatories and residential quarters have been proposed, under this scheme, at Agra and Calcutta as well as at a number of the pilot balloon stations on the main route, where buildings have had to be rented meanwhile at considerable distances from the aerodromes. It is expected that the programme of the various works will be carried out during the next three years.

Owing to the inauguration of new air routes and increased frequency in flying, the number of weather reports and forecasts issued to airmen by the various forecasting centres increased very considerably this year. Among the notable flights for which special arrangements were

made for the supply of weather reports and forecasts, mention may be made of the flight of 203 Flying Boat Squadron from Basrah to Australia and back in September and December respectively, the flights of the Under Secretary for Air in October and the McRobertson International Air Race from London to Melbourne in October for which a special officer was deputed to the Control Point at Allahabad.

Facilities were given to pilots and other aviators to study the weather charts and to discuss meteorological conditions with the Meteorological Officers. As in previous years arrangements were made for the training and examination in meteorology of candidates for Pilots' " B " license, and in all 28 candidates were trained or examined at Poona, Bombay, Karachi and Agra Meteorological Offices.

The normal activities of the department were continued as efficiently as possible. Warnings for cyclones, storms, depressions, thunder-squalls, and for heavy rain, and spells of cold weather were issued as usual from Poona and Calcutta to shipping in the Arabian Sea and the Bay of Bengal, to sea-ports around the Indian coasts, riverports in Bengal, and numerous Government Officers in railway, public works, agricultural or other departments. The issue of the daily weather reports at different centres, time-signal work at Calcutta and Bombay, solar observations at Kodaikanal, seismological and magnetic observations at Bombay, compilation and tabulation of climatological data, exploration of the upper air by routine pilot balloon ascents and periodical soundings with self-recording meteorographs continued to be carried on as usual. Fifteen first class and 253 second and third class observatories scattered over India, Burma, Afghanistan, Iran (Persia) and Arabia were maintained and about 160 observatories were inspected.

Owing to the increased frequency of aerial navigation, the need for the exchange of meteorological data between India and Indo-China assumed considerable importance, and a few trial broadcasts were arranged. The reception was not satisfactory and the proposal had therefore to be kept in abeyance until the question of suitable transmitting and receiving apparatus was settled by the Wireless Department. The daily exchange of a few data between India and Siam was decided upon as a tentative measure by mutual agreement betwen the two countries.

Co-operation was extended to the International Meteorological Committee, as in the previous year, in regard to collection, scrutiny and tabulation of all special observations made during the International Polar Year. The data for Indian seas and of several selected land stations in India and Burma were compiled and sent to the Deutsche Seewarte at Hamburg for the preparation of daily weather maps of the Northern Hemisphere.

On the scientific side, fair progress was maintained during the year. At Agra 77 sounding balloons were released and 38 retrieved of which 4 belonged to the batch sent up during the previous year. Some further work was done to develop the technique of pilot balloon ascents at night.

Experiments were made to devise a binocular theodolite by means of which it may be possible for the same observer who follows the balloon to record the altitude and azimuth readings of the theodolite. Assistance was given, as in former years, to Prof. K. C. Mehta of Agra College in his investigations on the transport of the spores for cereal rust. At Bombay a special study of the seismograms of the disastrous Bihar Earthquake of January 15th, 1934, was undertaken. The Meteorological Officer at Peshawar continued to co-operate with the local medical authorities in connection with investigations on the relation between local weather and the incidence of disease in the North-West Frontier Province. Some investigations on the thermal structure of cumulus clouds were also made. At Kodaikanal, in addition to the usual work of collection of statistics of solar prominences, the spectrophotometry of certain lines in the sun's spectrum at different points between the centre of the sun's disc and the limb, was undertaken during the year.

In south India, the sounding balloon work was somewhat restricted during the period under review; 80 meteorographs were released at Poona, Madras and Hyderabad (Deccan). Madras again proved to be the best centre for recovery of instruments, about 70 per cent. of those let off there being retrieved. Special experimental flights of small balloons were arranged at Poona for study of the vertical currents in the lower layers of atmosphere, caused by ground heating. Studies were also pursued on the physical structure of the atmosphere in the field of a tropical storm as revealed by data obtained from self-recording meteorographs attached to balloons. Past data of upper winds and upper air temperatures were also being collected and analysed for a discussion of the atmospheric circulation over India and neighbouring regions. Statistical studies were made with a view to extend Walker's Test so as to make it applicable for the estimation of the significance of any number of correlation coefficients selected from random samples.

Some work was done with the help of voluntary research students at Poona. Studies on the luminous radiation received from the night sky and the zodiacal light were continued. Experimental and theoretical investigations of atmospheric radiation were carried out in collaboration with the Agricultural Meteorology Branch. An apparatus on the model used in the Kew Observatory for the recording of the earth-air electric current was kept in constant action for some months and some interesting records were obtained, while another apparatus for the same purpose, devised in Poona and involving the use of thermionic valves, was under test to see how its performance would compare with the Kew type of instrument. Some improvements were made in the design of the experimental hydraulic seismograph. A series of experiments was carried out with a view to throw light upon the process of generation of electric charges on drops of different liquids broken by various mechanical methods. Some work was also done in regard to evaporation and its measurement.

The Agricultural Meteorology Branch was engaged in the investigation of the microclimates of different crops at Poona and on precision

observations on weather and crops side by side, besides other experimental items like the measurement of evaporation, effect of cover on soil temperatures, exchange of moisture between air and soil, and the measurement of percolation and the solar, terrestrial and nocturnal radiation. Various instruments for the measurement of plant temperatures by means of thermocouples, evaporation from free water surfaces as well as soils, screens for exposing instruments inside crops, etc., were designed and tested at the central Agricultural Meteorological Observatory which also served as a training ground for agricultural workers. The study of meteorological factors during frosty nights and the method of preventing damage to crops also engaged the attention of the Branch, and various statistical investigations with the help of past records of meteorological factors as well as agricultural data were in progress.

The Imperial Council of Agricultural Research at the meeting of the Advisory Board in February 1935, examined the 2nd annual report of the Agricultural Meteorology Branch and considered proposals for the extension of the scheme beyond the term of 3 years. The Advisory Board appreciated the work accomplished and sanctioned the extension of the Scheme for another two years in the first instance.

In accordance with the International Telegraph Convention adopted in Madrid in 1932, the Indian Post and Telegraph Department extended the concession of half rates to this department in respect of radio-telegrams containing exclusively meteorological observations or meteorological forecasts.

Marine Meteorology—Storm warning.

No change was introduced in the system of storm warnings for ports and shipping. Storm warnings for the Bay of Bengal and the surrounding areas continued to be issued from the Meteorological Office, Alipore, Calcutta, and those for the Arabian Sea area from the Meteorological Office, Poona. The number of ports on the warning list was 40 on the west coast of India and 28 round the Bay of Bengal. The latest weather information continued to be supplied as usual to shipping at sea by means of wireless weather bulletins issued twice daily on ordinary undisturbed days and more frequently on disturbed days. The total number of such broadcast messages issued by the Calcutta Office during the year was 1,776 as against 2,186 in the previous year and the number issued by the Meteorological Office, Poona, was 1,194 against 1,265 during the previous year.

Services to ports around Bay of Bengal.—Warnings were issued by the Meteorological Office, Calcutta, for 40 periods of disturbed weather or suspicious weather or probability of thundersqualls. Of these, 11 developed into depressions, and on 5 occasions the disturbances intensified into storms.

Twenty-eight port officers offered their remarks on the warnings issued to them. Nearly all of these officers expressed satisfaction with the warnings received by them. Criticisms or remarks on individual warnings

and other suggestions from Port Officers are always welcomed by the department and are critically examined as these help in improving the organisation. The total number of warnings issued to ports by the Meteorological Office, Calcutta, was 4,129 during the year under report.

Services to Arabian Sea Ports.—Warnings for disturbed weather were issued on 29 occasions, and on 2 occasions the disturbances developed into storms.

Twenty-seven Port Officers sent in their annual returns about the warnings issued to them. All of them stated that the warnings were timely and satisfactory in every respect and that no change in the present system was necessary. The total number of warning messages issued to ports by the Meteorological Office, Poona, during the year was 2,286.

Exchange of information with ships at sea.—The chief sources of marine data are wireless weather messages from ships at sea and extracts from weather logs of ships calling at the principal ports on the Indian seaboard. The object of the system of radio weather messages from ships is to help in increasing the efficiency of cyclone warnings. The system which was started in 1914 was suspended during the War, but resumed in 1921. Since that year the number of messages sent by ships in Indian waters has progressively increased and has now reached more or less a steady state. The following figures show the number of ships' messages from the Bay and the Arabian Sea during the year under report as well as in the previous years since 1921 :—

Year.	Ships' messages.	Year.	Ships' messages.
1921 22	649	1928-29 . . .	4,342
1922-23	656	1929-30 . . .	4,635
1923-24	2,237	1930-31 . . .	5,869
1924-25	3,635	1931-32 . . .	6,971
1925-26	3,689	1932-33 . . .	10,010
1926-27	4,282	1933-34 . . .	10,814
1927-28	4,835	1934-35 . . .	9,745

The figures indicate satisfactory co-operation between ships' Captains and this department. It is not possible to name here every steamship

that sent messages but those that sent 50 messages or more during the year are listed below along with the number of messages received from each :—

Name of ship.	No. of messages.	Name of ship.	No. of messages.
1. Alavi	50	30. Jalamohan	174
2. Aungban	163	31. Jalaveera	71
3. Akbar	69	32. Jalajyoti	68
4. Aronda	61	33. Jalavijaya	103
5. Badarpur	175	34. Jalaratna	95
6. Barjora	53	35. Karapara	71
7. Binfield	52	36. Karagola	74
8. British Sovereign	82	37. Khandalla	51
9. Baroda	113	38. Karoa	77
10. Chakdina	73	39. Khosrou	52
11. Chilka	69	40. Masimpur	220
12. Carthage	61	41. Mulbera	53
13. Clumberhall	50	42. Maharaja	97
14. Corfu	119	43. Marnix van St. Aldegonde	61
15. Ethiopia	148	44. Nirvana	51
16. Erinpura	203	45. Nurjehan	60
17. Ekma	115	46. Querimba	55
18. Ellenga	84	47. Rajula	147
19. Elephanta	62	48. Rohna	91
20. Egra	69	49. Rizwani	87
21. Gazana	54	50. Rawalpindi	54
22. Goalpara	62	51. Saugor	78
23. Hosang	105	52. Singu	144
24. Jalapalaka	143	53. Strathnaver	60
25. Jalarajan	88	54. Shropshire	51
26. Jalabala	66	55. Takliwa	50
27. Jalaputra	54	56. Talamba	50
28. Jalatarang	151	57. Victoria	66
29. Jaladuta	102	58. Vita	162

The second principal source of marine data is the log extracts collected by clerks in Calcutta and Bombay and the various steamship agencies. The British India Steam Navigation Company, the Peninsular and Orient Steam Navigation Company, the Scindia Steam Navigation Company, the Burma Oil Company, Limited, Rangoon, and the Asiatic Steam Navigation Company have standing arrangements with a number of their ships' Captains to copy and despatch extracts from weather logs in two kinds of forms, which are supplied to them for use during ordinary weather and during disturbed

weather respectively. The Port authorities at Rangoon also continued to render help by allowing the observers of the Time Ball and Tidal Observatory of the Port Commissioners to collect ships' data. Occasionally, in cases of specially important disturbed weather, logs of steamers were collected through the help of the Colombo Port authorities. A total of over 4,300 logs was recorded during the year.

Inland Weather warnings and forecasts.—Most of the officers to whom warnings for heavy rain and strong winds on land are issued from Poona and Calcutta were district officers, and officers of the Irrigation, Railway, Police, Telegraph and other Departments. The number of officers on the Poona warning list was 146. The number of officers on the Calcutta warning list was 147, including 15 officers of the telegraph department, 8 river ports, 11 river police stations, 43 division police stations, 3 sub-divisional officers (Revenue), and 67 other officers. In addition to these the number of officers in Bengal on the list of " Great Danger Warnings " was 460 including the 43 District Police Stations mentioned above. Apart from these specific warnings to individual officers, the Daily Weather Telegraphic Summary contains heavy rainfall forecast, and all its subscribers and others to whom the information becomes accessible thus receive these warnings. During the year under review the Meteorological Office, Calcutta, issued 3,153 inland warning messages including great danger warnings, special weather bulletins for river-crafts and warnings of the probability of thundersqualls in Bengal, while Meteorological Office, Poona, issued 1,558 inland warnings including warnings for low temperature. The number of telegrams of heavy rainfall sent direct to various officers by local meteorological observers was 592. Reports on the working of the inland warning system were received from 157 officers on the warning list of Poona and Calcutta Offices, and almost all of them expressed satisfaction with the warnings issued.

A few recipients of warnings against thundersqualls in Bengal, were not completely satisfied and offered useful criticisms. Such criticisms are always of great value in as much as they assist the department in considering methods of improving the forecasts.

Aviation Forecasts and Weather Reports.—The forecasts and weather reports on the main trans-India route continued to be supplied by the Meteorological Offices at Karachi and Calcutta. The Quetta and Peshawar Offices, as usual, supplied aviation forecasts to the Royal Air Force planes. The Meteorological Office, Poona, issued forecasts to aviators in South India, including the Tata Air Mail Service between Ahmedabad and Madras. Besides forecasts to the regular air mail services of the Imperial Airways, Indian Trans-Continental Airways, and Indian National Airways, route forecasts were supplied on requisition to various individual fliers, members of the Indian Flying Clubs and the Royal Air Force squadrons. During the year the Karachi-Lahore Air Mail Service was inaugurated and the Karachi-Madras and Karachi-Calcutta Air Mail Services were duplicated and this resulted in increased demands for weather reports and forecasts.

To meet the demands of greatly increased air-traffic the meteorological arrangements on the main trans-India air routes were reorganised and the distribution of weather forecasts twice daily from Calcutta and Karachi Meteorological Offices was put on a routine basis with effect from 1st October 1934 as already indicated under the Chief Features. The meteorological organisation in India falls far short of that recommended by the International Convention. Nevertheless, it was gratifying to receive appreciatory remarks from various aviation interests.

During the period under review a few complaints were received from some aviators about the late receipt of upper wind data, or delay in the supply of forecasts or current weather reports. Attempts were made to meet these as far as the present organisation would allow. With the introduction of the scheme of the issue of forecasts and pilot balloon data on a routine basis, the occasions for such complaints have disappeared over many parts of the routes, but over those parts where early morning flights are the general rule, it still remains as a standing complaint. Until the requisite staff and equipment are available for pilot balloon operations in darkness no further improvement in the situation seems possible.

The total number of aviation forecasts—as distinct from aviation weather reports—issued during the year was 5,670 of which Karachi was responsible for 2,531, Calcutta for 2,208, Poona for 464, Quetta for 216, and Peshawar for 251. The number of upper wind reports, special current weather reports, and voluntary warnings of adverse weather and improvement thereof issued by observers along the chain of current weather stations is given in the following table:—

Name of Station.	No. of upper wind reports supplied (from 1st April 1934 *to 30th September 1934).	No. of special current weather reports supplied (from 1st April 1934 to 31st March 1935).	No. of *dangermet* and *improvemet* messages issued (from 1st April 1934 to 31st March 1935).
1. Karachi . . .	756	240	78
2. Jodhpur . .	..	160	12
3' Delhi . . .	..	58	21
4. Allahabad . .	110	154	26
5. Calcutta . .	116	296	79
6. Chittagong . .	68	303	56
7. Akyab . . .	229	488	78
8. Sandoway . .	47	379	32
9. Bassein . . .	..	454	6
10. Rangoon . .	167	480	14
11. Victoria Point. .	102	138	..

*NOTE.—From 1st October 1934, the upper wind data from the pilot balloon stations along the trans-India air route began to be broadcast along the wireless chain twice daily as a routine, and was also exhibited at the principal aerodromes on " Weather Notice Boards ".

In addition to the above, 540 current weather reports were supplied by observatories along Ahmedabad-Poona-Madras route for the Tata Airmail Service.

Offices and Observatories.

In regard to the "Functions and Organisation of the India Meteorological Department" a reference is invited to the 1935 edition of the pamphlet on the subject, issued by the Department of Industries and Labour.

Headquarters Office, Poona.—The scientific activities in this office have been briefly indicated under the Chief Features. Seventeen meetings of the Colloquium were held; the discussion at each meeting being opened by a member of the staff or one of the research students, or some outside scientific worker who took as his subject either his own original work or a recent important paper published in an extra-departmental scientific journal. Co-operation was extended to the International Meteorological Commission in the scrutiny and tabulation and editing of all observations made in India for the International Polar Year Commission.

The 22nd session of the Indian Science Congress was held at Calcutta and 5 officers of the department were deputed to attend its meetings. During the congress an interesting symposium on "The North Bihar Earthquake of January 15th, 1934" was held at a joint meeting of the sections of Mathematics and Physics, and Geology, in which officers of the department deputed to attend the congress, took part.

His Excellency the Governor of Bombay and Lady Brabourne paid a visit to the Headquarters Office at Poona on 20th July 1934.

The activities of different sections of the Headquarters office are briefly described below :—

(*a*) *General Section.*—This section deals with matters relating to the administration of the Headquarters and Sub-offices including such items as budget, accounts, establishment, general registry and technical questions relating to aviation and matters involving fresh expenditure as well as arrangements for the co-ordination of technical work in the department.

The reorganisation of the meteorological arrangements for services to aviators along the trans-India air route gave rise to a considerable amount of correspondence and additional work in the section. A scheme of routine transmission of weather forecast, and upper wind report to aviators twice daily by wireless, along with arrangement for the supply, whenever occasion demanded, of heights of low cloud was drawn up and introduced with effect from 1st October 1934 on the air route between Karachi and Victoria Point. Arrangements were also made for the exhibition of these reports and forecasts on notice boards at the principal aerodromes along the route. New forms for exhibition of these reports were devised and printed, and duly distributed to observatories and aerodromes concerned for their use.

The Government of India with the concurrence of the Secretary of State for India decided to sanction a capital grant for the development and organisation of air-routes in India. Under meteorology, the proposals included building projects for offices, observatories, and residential quarters at Karachi (Drigh Road), Agra, Calcutta, as well as at a number of stations along the main route in Burma. It is expected that the programme of the various works will be completed during the next 3 years.

A scheme of the most essential meteorological facilities for the Karachi-Lahore Air Mail Service started by the Indian National Airways, Limited, was prepared and submitted to Government. The scheme was duly sanctioned by Government and brought into force with effect from 1st January 1935.

(*b*) *Weather Section.*—The functions of this section have been partly outlined in previous pages dealing with storm and heavy rain warning. This section is responsible for the issue of daily weather telegrams which appear regularly in newspapers, the Daily, Weekly, Monthly Weather Reports and for the preparation of portions of the Annual Summary of the India Weather Review. During the year, the Karachi-Madras Air Mail Service operated by Tata Sons, Limited, Bombay, was duplicated and arrangements were made for the supply of additional forecasts to the pilots of the air mail. In view of the diversion of the route of this service *via* Hyderabad, arrangements were also made for the supply of current weather reports to the Air Mail pilots along the new route.

A climatological note on the weather conditions along Lahore-Rawalpindi-Srinagar Route was prepared and supplied to the Indian National Airways, Limited, Delhi. Two climatological notes on the general weather conditions over the routes (*i*) Karachi-Udaipur-Gwalior-Allahabad-Calcutta and (*ii*) Delhi-Allahabad-Calcutta-Victoria Point were supplied to the Royal Air Force Headquarters, New Delhi. General weather summary and climatological tables for Bushire-Tavoy air route for October were supplied to the Aero Club of India and Burma, Simla, in connection with the preparation of a pamphlet by them for the London-Melbourne Air Race. A short summary of weather in India throughout the year was prepared and supplied to the Burma Shell Oil Co., Ltd. The upper wind data at Karachi, Allahabad, Calcutta and Rangoon at different heights for the period 1928-1933 was supplied to Mr. Robert Faurisson of Singapore. Climatological tables for October for the Baghdad-Singapore air route were supplied to the Aerodrome Officer, Wingfield Aerodrome, Cape Town, and another set of climatological tables for the route Madras-Chanda-Jhansi-Delhi-Sialkot to the Madras Flying Club.

In connection with the MacRobertson International Air Races in October 1934, Mr. S. Basu, Meteorologist, Weather Section, Poona, was deputed to Allahabad (Bamrauli) aerodrome, one of the main control stations, to supervise generally the meteorological arrangements, made there for the air races, and to render such other help as might be required by the pilots.

Three candidates for the pilots' " B " license Examination were given training in practical and theoretical meteorology. Five members of the Bombay Flying Club were also given some training in drawing weather charts. A revised syllabus and rules for the training and examination of pilots' " B " License were drawn up.

The revised edition of 1931 Surface Weather Code was received from press and brought into use.

(*c*) *Observatories section.*—This section continued to administer and arrange for the inspection of departmental observatories in Central and South India. Inspection of 74 observatories was undertaken. Two 3rd class observatories (with part-time observers) were closed down. A pamphlet entitled " Service Instructions for part-time Observers of India Meteorological Department " detailing the procedure of appointment, removal and change of observers, for drawing monthly meteorological allowance bills and leave salary, and rules regarding imposition of penalties on observers for unsatisfactory work, the maintenance of service books, etc., was published and distributed to all observers.

In connection with the diversion of the Tata Air Mail Service *via* Hyderabad, Current Weather Observatories were started at Rentachintala Jadcherla, Vinukonda and Allagadda. The stations at Wai, Khandala and Bagalkot were closed down.

Arrangements were made for special observations at 17 hrs. from 4 observatories during May to August 1934 in connection with the Deutsche Himayalan Expedition of Nanga Parbat.

(*d*) *Intruments Section.*—As in past years, the section continued to be responsible for the purchase, test, standardisation and repairs of meteorological instruments and their issue to all surface observatories of the department as well as for the supply of forms and stationery to them. The method of stock-keeping was systematised and definite rules drawn up in that connection after correspondence with the audit authority.

During the period under review 861 instruments were issued to departmental observatories, about 1,200 items of instruments and stores were issued to officers and research students at headquarters, 54 instruments were loaned, 898 instruments tested and 333 instruments repaired. The replacement of old and obsolete instruments by new ones of standardised types was in progress and by the end of the period 197 anemometers, 106 wind vanes and 59 barometers were thus replaced.

Specifications of 17 instruments to suit the requirements of this Department were drawn up and sent to the India Store Department to guide supplies. In order to guide purchase of suitable thermometers for meteorological work by outside organisations and individuals, standard specifications adopted for departmental thermometers were drawn up and supplied. Representative local firms and manufacturers' agents were also supplied with a copy of these specifications.

Histories of corrections of barometers and thermometers maintained at all the observatories of the department were collected, scrutinised and brought up-to-date as these form a very useful record in judging the performance of the instruments and effecting their replacements or re-determination of their corrections whenever necessary.

Technical advice was given on request to the Bihar and Orissa Government and the Meteorological Reporter to the Government of Jammu and Kashmir regarding the opening of seismological stations at Patna and Srinagar respectively. The departmental seismic code was revised.

Work on atmospheric electricity at Poona and on snow gauges at Quetta was continued. Some improvements and additions were made in the test laboratory.

Fifty requests for information regarding specifications, installation, etc., of meteorological instruments were complied with. About 1,300 visitors were shown round the office and observatory and small exhibitions were arranged on 11 occasions during the period under review. Exhibits were being collected and preliminary arrangements being made for setting up a permanent meteorological museum at the Poona Office.

(*e*) *Marine Section.*—The normal duties of the section, namely, the co-ordination of the work of collection, examination, and study of ship's weather logs and of maintaining contact with the shipping interest at Bombay were carried on as in previous years. The collection, scrutiny and tabulation of all observations in Region D (with the exception of the observations from Kodaikanal, Quetta, and Srinagar) made for the International Polar Year Commission were completed. The data for Indian Seas of March to August 1933 inclusive, were extracted, compiled and sent to the Deutsche Seewarte for the preparation of daily weather maps of the Northern Hemisphere for the International Meteorological Committee. In addition to the marine meteorological observations made on board H. M.I. S. "Investigator", the Commander was requested to have pilot balloon observations made whenever possible during the marine survey season ; the necessary additional instrumental equipment was sent to the ship. Data of marine observations at 3 daily periods were received and scrutinised.

The question of revising the hours at which ships at present record and wireless routine and special observations in the Arabian Sea and the Bay of Bengal, and to make them identical or as near the international hours of observations at sea as possible was discussed and new hours considered. In order to study the feasibility of these, the hourly distributions of sea observations from ships in the Bay of Bengal and the Arabian Sea for typical months were examined.

As in previous years, essays in Meteorology by Cadets of the I. M. M. T. S. "Dufferin" were judged and the usual prize of an aneroid was sent to the Captain Superintendent for presenting to the Cadet who scored the highest marks in meteorology.

(*f*) *Upper Air Section.*—Sounding balloon work was somewhat restricted during the year under review. Only 38 meteorographs were let off from Poona ; 26 were let off from Madras and 16 from Hyderabad (Deccan) mostly during October and November. Thirtyone out of the above total of 80 have been recovered of which 19 were out of those let off from Madras. Observations of upper air temperatures and humidities continued to be made from aeroplanes by the Royal Air Force at Peshawar, Quetta and Karachi and the data were worked out at Poona in a form suitable for publication ; the results are included in the monthly publication of Upper Air Data.

Observations of heights of low clouds at Poona, Bombay and Madras were made during the respective monsoon seasons. Observations of 92 pilot balloon ascents from H. M. ships in Indian waters were received by post and the results were worked out in a form suitable for comparison with our data. A revised Code for reporting pilot balloon winds was introduced with effect from 1st October 1934. Tables of frequencies of normal upper wind directions and velocities at 4, 6, 8, and 10 km. were worked out, using all data up to the end of 1931.

Pilot balloon and other data of Region D (according to the classification of the International Upper Air Commission) for the years 1930 and 1931 were sent to the President of the Commission. The special upper air data collected during the Polar Year August 1932 to August 1933 was also edited and forwarded.

(*g*) *Statistical Section and Library.*—This section was formerly called the library section. The duties of the section comprise statistical work connected with the issue of seasonal precipitation forecasts and with climatology. The care of the library, the editing and distribution of departmental publications and the supply of general meteorological information in reply to enquiries are also in charge of the Section.

Statistical studies included attempts to improve the reliability of the existing forecasting formulæ not only by the addition of new factors but also by weeding out some of the existing factors which were shown to be of doubtful significance by the Performance Test. An extension of Walker's test was also under consideration. Five long-range forecasts were issued during the year and all these came out successful. Since 1931 when the Performance Test was begun to be applied, 20 out of 22 forecasts issued were successful.

The number of books, pamphlets and periodicals either purchased or received in exchange for publications of the department or as complimentary copies was 735. Shelf-listing of books and periodical publications in the library was completed and the preparation of a catalogue of periodicals was taken up. Seven Scientific Notes were either published or sent to Press during the year and the routine publications issued as usual. An English translation of the International Cloud Atlas (Tropical Atlas) was also published for the use of the department. Appendix B (page 30) gives a list of the publications issued by the department as

well as of papers and contributions by the members of the staff to non-departmental journals, Indian and foreign. The number of addresses on the free distribution list of the departmental publications was 376. About 375 enquiries for climatological and meteorological information were answered.

The routine activities of the Climatological Branch which consist of scrutinising the accuracy of records of surface meteorological data, preparation of meteorological tables for the routine publications of the department and supply of periodical meteorological reports and data to various Government and Public Officers, were carried on satisfactorily.

The usual advisory functions of the Director-General of Observatories, with regard to the registration of rainfall, inspection of raingauges and the publication of the provincial rainfall tables were also carried out. Arrangements were completed for the collection and publication of rainfall statistics of those Indian States in the Bombay Presidency, the Central Provinces and Bihar and Orissa, which have been placed in direct political relationship with the Government of India. The publication of rainfall tables of the North-West Frontier Province and Kashmir was transferred to the local authorities.

(*h*) *Agricultural Meteorology Branch.*—During the year under review this branch entered the 3rd year of the restricted scheme. Contact with numerous agricultural workers in the country was maintained, and the limited resources of the scheme were utilised to a large extent in investigating problems which come under the " biological " or " experimental " aspects of Agricultural Meteorology.

The programme on the " experimental " side was mainly conducted at the Central Agricultural Meteorological Observatory, Poona, which is also serving as a training ground for Agricultural workers, more than a dozen of whom came from different provinces or States during the year under review. Various instruments for the measurement of plant temperatures by means of thermo-couples, evaporation from free water surfaces as well as soils, percolation gauges, screens for exposing instruments inside crops, etc., were designed locally and tried out at the observatory. Some of these instruments are already in use at a few agricultural farms in India. Facilities are available at the observatory for conducting investigations on (1) local climatology, micro-climatology, soil meteorology, (2) effective rainfall, (3) evaporation from water and soil surfaces, (4) solar, terrestrial and sky radiations, etc.

Investigational work on the micro-climates of the " open " and of different crops was continued. The systematic variation of climates with environments as well as the correlations of conditions in the open with those inside crops are being discussed in a number of papers. The study of micro-climates has brought to light the facts that during clear season, (1) the lowest temperature is recorded not at the surface but at some distance above the ground both in the " open " and " inside crops " and (2) the water lost to the atmosphere by soil due to evaporation during the day is more or less regained by absorption from the atmosphere at night.

Progress was also made in the study of soil temperatures with relation to the colour of the soil by laying out a series of plots covered with thin coatings of representative soils from different parts of the country. Some of the soil covers were found to profoundly modify the climate of the local soil below. The effect of wetting the surface with known quantities of water and of covering the soil with vegetation were also under investigation.

Under evaporation the work included the comparison of different types of instruments mostly of local construction. For study of percolation a series of locally designed gauges filled with different depths of Poona soil was set up. With regard to radiation, measurements were made of the (1) intensity and spectral distribution of solar radiation, (2) intensity of total radiation from the sun and the sky with a self-recording solarigraph, (3) intensity of radiation from night sky and (4) occasionally the albedo of different types of soils, surfaces of vegetation, etc. These data provide complete information for evaluating the proportion of solar energy that contributes towards the heat content of the soil, and that is lost to the space as terrestrial radiation.

The scheme of crop-weather precision observations was tried out (i) on wheat and jowar at Poona, (ii) on rice at Karjat and (iii) on bajri at Baroda. At Karjat and Baroda the valuable co-operation of the Agricultural officers was available for this work. The study of (*a*) meteorological factors during frosty nights, (*b*) statistics of past cold waves in India, (*c*) method of preventing damage to crops, was also undertaken by the Branch. During the intense cold of January 1935, a special camp observatory was set up in a vineyard at Nasik to study the conditions during frost. The photograph in frontispiece is of interest in this connection. Arrangements were made as in the previous year, to issue frost warnings to the Nasik area, and these warnings were much appreciated by the vine growers.

The statistical section of the Branch was mainly engaged in (1) analysis of data collected by the Central Agricultural Meteorological Observatory, (2) the study of meteorological factors having an important bearing on agricultural problems, (3) the analysis of meteorological and yield data of selected experimental farms and the analysis of acreage and yield statistics of cotton in India in relation to the meteorological and other related factors. An idea of the work done can be had from the list of papers given in Appendix B (page 30).

The co-operation of the Branch was extended to the agricultural departments or workers in the different provinces and Indian States by training workers in Agricultural Meteorology, advising about meteorological equipments and repairing or standardising instruments. Special mention may be made of the help given to the officers-in-charge of the different schemes of the Imperial Council of Agricultural Research, *e.g.*, Sugarcane, Dry Farming and Locust Research Schemes. Six voluntary research students were doing research work under the guidance of the Agricultural Meteorologist.

Upper Air Observatory, Agra.—This observatory has the administrative control of all the pilot balloon stations of the department except those at other regional centres such as Karachi, Calcutta, Poona, or Bombay. In connection with the Karachi-Lahore Air Service a new pilot balloon station was opened at Sukkur, and arrangements were made for taking a second flight at Lahore. The long-contemplated shift of the upper air observatory at Ajmer to Jodhpur was also effected. The total number of upper air stations under direct administrative control of Agra is 28, and under its technical control is 36. The output of hydrogen during the year was 209,418 cubic feet as against 209,120 cubic feet during the previous year.

The scientific activities of the observatory continued on a restricted scale on account of financial difficulties. Seventy-seven sounding balloons were sent up and 38 retrieved of which 4 belonged to the lot left off during the previous year. A new and improved apparatus for calibration of sounding balloon meteorograph was installed, and dies for punching some parts of the Dines meteorograph were made to economise labour. Technique for pilot balloon work at night was further developed. Experiments were made to develop a Binocular Theodolite by which it may be possible for the same observer who follows the balloon to give the altitude and azimuth readings of the theodolite.

Experiments to find out better and cheaper balloons and balloon material were continued. The gas cylinder testing plant was completely installed and tested. A transformer was installed with necessary disconnecting links and switches for running during holidays and at night to economise electric consumption.

The tabular statements of International Pilot Balloon and Sounding Balloon ascents from January 1932 to August 1933 were prepared for transmission to the International Commission. The new Pilot Balloon Code of 1934 was brought into use at all the observatories. Detailed instructions for the supply of the height of base of low cloud were issued to stations on the trans-India air route. Two candidates were examined and one trained in elementary meteorology for the pilots' "B" licence. Classes in meteorology were also held for some students of the Agra University. Copies of pilot balloon data upto 4 km. above sea level of Alipore, Allahabad, Drigh Road, Rangoon and Victoria Point from 20th to 30th October for 1931 to 1933 were prepared and supplied to competitors of the London-Melbourne Air Race. As in previous years assistance was given to Dr. K. C. Mehta of the Agra College in his investigations on the transport of the spores for cereal rust.

The observatory, as usual, prepared after scrutinising the Upper Air Data, the manuscripts of monthly means of upper wind, frequency tables for directions of movement of clouds and ground winds, seismic data, sounding balloon data, and daily pilot balloon data for routine publications of the department. Duties of a first class surface observatory and seismological station were also carried on as usual. The number of upper air observatories inspected during the year under report was 14.

Colaba and Alibag Observatories.—These observatories form the departmental centre for geophysical studies. As in previous years, the routine meteorological, seismological, magnetic, and atmospheric electricity work was carried on satisfactorily. The Colaba Observatory maintained a time service for the port of Bombay and continued to stock the Royal Indian Navy chronometers and watches for maintenance and rating, the average number of the instruments for daily rating being 66.

Copies of observatory volumes for 1932 were distributed and the volume for 1933 sent to the press. A number of photostat copies of Colaba seismograms, particularly of " the North Bihar Earthquake of January 15, 1934 " and its aftershock were sent on request to several Indian and foreign seismological institutes. Twelve seismic radiograms relating to earthquake shocks of moderate or great intensity were sent to the Kew Observatory, London. A preliminary study of the seismogram of the North Bihar Earthquake of the 15th January 1934 was made with a view to determine its epicentral region. The departmental seismic code was remodelled on the lines of the international seismic code to make provision for reporting of all important seismic phases.

Registration and measurements of the various magnetic elements were continued at the Magnetic Observatory at Alibag. In conformity with the recommendations of the International Commission for the Polar Year, 2 sets of ferro-prints of the Alibag magnetograms for the Polar Year were prepared for supply to the International Commission at Copenhagen and to the Department of Terrestrial Magnetism of the Cargnegie Institution of Washington.

The Gestetnered Daily Weather Report giving summary of the principal feature of weather over Western India based on the material telephoned from Poona was issued regularly for the period 1st May to 30th November. The collection of weather logs from ships calling at the Bombay port and the standardisation of their barometers were carried on as usual. Measurements of low cloud ceilings by balloon ascents were continued thrice daily during the monsoon. Four pilots of the Bombay club were given training in elementary meteorology for " B " licence.

Alipore Observatory and Meteorological Office.—The principal functions of storm warning for the Bay of Bengal, heavy rainfall warnings for northeast India and the surrounding areas, thundersquall warnings for Bengal, and the issuing of weather reports and forecasts to aviators including the regular air mail services on the air route between Allahabad and Victoria Point were carried on as satisfactorily as possible. On account of the duplication of the Karachi-Calcutta air mail services, a considerable increase of work occurred in the Calcutta Office.

The Calcutta Office continued to publish the Calcutta Daily Weather Report as usual throughout the year. This office was also responsible for the administration of 102 surface observatories. The meteorological seismological, time-determination and time signalling duties of Alipore Observatory were carried on as usual. Special sets of cloud observations were recorded for the International Meteorological Commission. The

work of testing and standardising meteorological instruments of the Mathematical Instrument Office, Calcutta, of the Chemical Examiner to the Government of Bengal, Calcutta, and of ships' Captains was also done as usual. The collection and examination of logs for the Bay of Bengal from ships and the supply of meteorological and other information to the public was also attended to as in previous years.

Special weather reports and forecasts were supplied on request on various occasions to officials and private individuals, as for example, to Raja Saheb of Rewah, Bahraich, United Provinces ; Chairman, District Board, 24-Parganas, etc. Special weather bulletins for ocean and river craft were issued to Indian State Broadcasting Co., on 95 occasions.

Arrangements were made with the Indian State Broadcasting Company to broadcast the Calcutta Daily Weather Report in English, as well as Hindustani in addition to Bengali which has been a regular feature of their programme in the past years. In connection with the Calcutta Aerodrome project, arrangements were made for recording visibility observations at different sites in and around Calcutta.

In connection with MacRobertson International Air Races between England and Australia, special instructions were issued to observatories participating in the current weather scheme to be on continuous watch during the period of the Air races. ' Spemet ' messages were supplied at the interval of every two hours by the Alipore Observatory for 7 days, while several weather reports and forecasts for different sections of the route, Calcutta-Victoria Point, were transmitted by land line to Allahabad Aerodrome for the benefit of the competitors in the Air race.

An exhibition was arranged at the Alipore Observatory in connection with the visit of the delegates of the 22nd session of Indian Science Congress held at Calcutta.

Thirty-one departmental and 4 non-departmental observatories within the area of the Calcutta Office were inspected.

Meteorological Office, Karachi.—The office continued to furnish aviation weather reports and forecasts for the main air route from Bahrein and Bushire on the west to Allahabad on the east, and also for the air route between Karachi and Ahmedabad. The responsibility of this office in respect of weather forecasts and reports was further increased by the inauguration of a regular air mail service between Karachi and Lahore. Forecasts for the route Karachi-Jodhpur-Delhi and other routes were also supplied to Royal Air Force whenever required.

The synoptic and other observational data were supplied to the Royal Air Force forecasting centres at Quetta and Peshawar and to the Meteorological station at Hinaidi as in the past. The supply of observational data direct from some of the stations in Mekran and the Persian Gulf to Meteorological Office, Hinaidi, was also continued. The total number of surface and upper air reports supplied through the Royal Air Force Wireless station for Royal Air Force forecasting centres from this office and the Drigh Road Observatory was 4,412 and the number of surface and upper air reports received in this office through Royal Air

Force W/T station at Drigh Road was 2,016. The number of weather reports and route-forecasts supplied to Royal Air Force planes and squadrons was 187. Thirty-six enquiries regarding upper air data from the local Royal Air Force aircraft depot were attended to. Upper air temperatures recorded during aeroplane ascents were received on 16 occasions with the assistance of the local Royal Air Force depot, Drigh Road.

The Karachi Daily Weather Report continued to be published and received increasing support from the public during the period under review. Warnings for adverse weather and anticipated rainfall were issued on 329 occasions and about 243 telephonic enquiries from public during disturbed weather were attended to.

Meteorological information was supplied to several Government officers and the public. Facilities were also given to the representatives of the Locust Research Entomologist under the Imperial Council of Agricultural Research and Professor Pithawalla of the Karachi Engineering College to extract meteorological information from the records of this office. A note on meteorological conditions for Hardwar-Gauchar route was supplied to the Himalaya Air Transport, Ltd. Percentage frequencies of surface wind data at Sukkur for different months were supplied to the Director of Civil Aviation in India.

The introduction of Current Weather scheme west of Karachi was under consideration. As a preliminary measure, however, arrangements were made at Gwador and Bahrein for the supply of reports regarding the commencement of adverse phenomena and of their cessation. Pilots of Imperial Airways and Indian Trans-Continental Airways frequently visited Karachi office to study the weather charts and discuss weather conditions. Meteorological logs were regularly received from pilots of Imperial Airways, Indian Trans-Continental Airways, and Tata & Sons.

During McRobertson International Air Races between England and Australia, continuous watch was maintained at Jodhpur and Drigh Road Observatories for the supply of local weather reports. Special arrangements were also made for the issue of two weather reports and forecasts for Bushire-Allahabad route morning and afternoon upper air reports for Drigh Road and Jodhpur by W/T to Meteorological Office, Hinaidi, during the period of the race.

The 3rd class observatories at Naushahro and Lyallpur were raised to 2nd class. The control of observatories at Bahraich, Lucknow, Cawnpore, and Fatehpur, which were previously administered by Calcutta Office, was transferred to this office.

The total number of observatories administered by Karachi Office was 78. Forty-five of these observatories were inspected during the year. Ten members of the Karachi Aero Club were trained in elementary Meteorology for Pilots' "B" license and 3 of these passed this examination.

The observatory at Drigh Road discharged all its functions as a first class surface and upper air observatory as well as that of an

auxiliary centre. It also served as a medium of supply of weather reports and forecasts to aviators departing from Karachi.

Kodaikanal Observatory.—The solar and astronomical researches during the calendar year, 1934, have been summarised in the Annual Report of the Kodaikanal Observatory. The routine work of the observatory was carried on satisfactorily. Daily character figures of solar activity as regard Hα bright flocculi and Hα dark markings for the year 1934 were communicated to the Observatoire Federal, Zurich, for publication. Daily character figures for calcium flocculi from Kodaikanal photographs were furnished to the Solar Physics Observatory, Cambridge. Three staff meetings were held during the year for discussion of important scientific topics.

Co-operation with other observatories for prominence statistics under the auspices of the International Astronomical Union was continued. The spectrohelioscope from the Mount Wilson Observatory was set up and regular observations of the sun with it commenced from April 1934.

The spectrophotometry of certain lines in the sun's spectrum at different points between the centre of the sun's disc and the limb was undertaken during the year. Samples of dyed cloth and paper received from the Wool Industries Research Association, Leeds, were exposed to sunlight for specified number of hours and under prescribed conditions to test their fading.

Meteorological Office, Quetta.—This office continued under the charge of an officer deputed from the Indian Meteorological Service but paid by the Royal Air Force. A general inference and forecast of weather over Sind, Baluchistan and the Punjab was issued by wireless each morning except on Saturdays to the Air Depot, Karachi, and forecasts for the next 24 hours continued to be issued each morning (holidays excepted) for the next 24 hours to the General Officer Commanding, Western Command, Officers Commanding No. 3 (Indian) Wing, Royal Air Force, Nos. 5 and 31 Squadrons and Royal Air Force Pilots notice boards. In addition to the above, route forecasts and special weather reports were supplied to the Royal Air Force whenever asked for. 216 route forecasts and 43 special weather reports were issued during the period in question.

The daily routine duties of a first class surface observatory and a pilot balloon station were carried on as usual. Various meteorological data were supplied to the Royal Air Force and other local Government officials. The Royal Air Force flying machines continued to record meteorological observations of upper air temperature and pressure, and during the year 250 sets of such observations were taken at Quetta.

Meteorological Office, Peshawar.—This office continued in the charge of a Royal Air Force Meteorological officer who is under the technical control of the Director General of Observatories. A weather report and forecast for the area North-West Frontier Province, Sind, Punjab, north Baluchistan was issued daily by this office (except on Sundays and special holidays) at about 8 hrs. I. S. T. through Royal Air Force wireless to

Miranshah, Kohat, Risalpur, Lahore, Ambala and Delhi. A more detailed weather report and forecast for the Peshawar District was also issued daily at about 8 hrs. I. S. T. to the Group Headquarters, Royal Air Force, Peshawar Brigade Headquarters, and Royal Air Force Peshawar district Headquarters. Heavy rainfall warnings were issued periodically to the local canal office of the Public Works Department and special warnings for storms, squalls, poor visibility, etc., to the Royal Air Force Military and Civil authorities.

Special forecasts were supplied for a number of smoke trials carried out by the Chemical Defence Research Establishment, Rawalpindi. 251 route forecasts were issued to the Royal Air Force units and 64 'meteor' telegrams were supplied to the Artillery Practice Camps. Miscellaneous data, reports, and forecasts were supplied to several offices and institutions such as Anti-malaria Office, Canal Office, Chemical Defence Research Establishment, Peshawar Vale Hunt, Gaumont British Film Co., etc.

This centre also continued to function as a first class observatory and pilot balloon station. Observations of upper air temperature through the agency of the Royal Air Force machines were taken on 347 days during the year.

In addition to the investigations carried out by the Meteorological Officer mentioned under the Chief Features, a note entitled "Scent and Weather" was prepared by him for the Masters of Fox-hounds Association, India.

Other Observatories.—The numbers of observatories of various classes are shown in the table below, which also gives the corresponding figures at the end of the previous year. A description of classification of these observatories is given in Appendix C.

	On 31st March 1935.	On 31st March 1934.
I Class	15	15
II Class	168	166
III Class	85	86
IV Class	23	22
V Class	24	24
Non-instrumental	15	15
* Total .	330	328
Non-departmental	60	61

* This total includes the non-departmental observatories whose number is shown separately in the next row.

The records of the non-departmental observatories were scrutinised by this department and in most cases utilised in the daily weather reports and other departmental publications. The importance of these observatories need hardly be emphasised and the co-operation of the Indian States and other public bodies, who maintained them for the furtherance of the study of Indian meteorology, is much appreciated. Among these may be mentioned the Kingdom of Nepal and the States of Bahawalpur, Baroda, Bhopal, Bikaner, Cooch Behar, Hyderabad, Ichalkaranji, Jaipur, Jhalawar, Kashmir, Miraj, Mysore, Nawanagar and Travancore, the municipalities of Ahmedabad, Coonoor, Murree and Mussoorree and the Agricultural Departments of Bombay and the Punjab.

Rainfall Registration.

The rainfall data collected by the provincial rainfall organisations, for which the Director General of Observatories is the consulting authority, are published in the provincial rainfall tables, which are collected and issued in a single volume for the whole of India by this department. The number of stations included in the organisation in the different provinces and the number inspected during the year, together with corresponding figures for the previous year, are given in the following table. On the whole the work of rainfall registration was carried out satisfactorily throughout India.

Rainfall Registration during 1934-35.

No.	Province.	Number of raingauges at the end of			Number of raingauges inspected.			Remarks regarding the condition of raingauges.
		1934-35.	1933-34.	Changes.	1934-35.	1933-34	Changes.	
1	Burma . . .	214	215	—1	205	214	—9	Satisfactory.
2	Assam . . .	128	128	0	96	111	—15	Do.
3	Bengal . . .	236	235	+1	204	187	+17	Do.
4	Bihar and Orissa .	276	276	0	261	259	+2	Do.
5	United Provinces .	269	269	0	264	265	—1	Do.
6	Punjab . . .	195	196	—1	176	121	+55	Do.
7	Jammu and Kashmir	30	30	0	7	13	—6	Do.
8	N.-W. F. Province .	30	30	0	26	24	+2	Do.
9	Baluchistan . .	78	73	+5	74	69	+5	Do.
10	Bombay . . .	261	262	—1	218	215	+3	Do.
11	States in Bombay Presidency.	80	72	+8	46	37	+9	Do.
12	Rajputana . .	185	184	+1	167	165	+2	Do.
13	Central India . .	122	122	0	106	105	+1	Do.
14	Central Provinces .	167	167	0	163	165	—2	Do.
15	Berar . . .	42	42	0	40	42	—2	Do.
16	Eastern States . .	46	46	0	46	46	0	Do.
17	Hyderabad . .	55	53	+2	0	0	0	Do.
18	Mysore . . .	75	75	0	75	75	0	Do.
19	Coorg . . .	20	20	0	18	18	0	Do.
20	Madras . . .	514	514	0	493	479	+14	Do.

Heavy Rainfall Reports.—Heavy rainfall is sometimes so very local that small unrepresented areas can have as much as 10 inches without the present net-work of daily reporting stations conveying the least suggestion of the local deluge. To obtain reports of such local heavy rain promptly for the daily weather report, it was arranged 14 years ago that observers at the provincial raingauge stations should telegraph to forecasting centres falls of 5 inches or more. The number of such telegrams received during 1934-35 was 189.

Snowfall Registration.—Information about the distribution and the time of occurrence of snowfall in the Himalayas and the Afghan mountain areas was on the whole tolerably complete and the thanks of the department are due to the various officers who collected and forwarded the reports.

Concluding Remarks.

The Meteorological Department owes a large part of its usefulness to the sympathetic assistance it receives from other departments. Officers of various Government departments help the meteorological work as Honorary Superintendents of Observatories or in other capacities. The Posts and Telegraphs Department assists this department in the rapid transmission of meteorological information particularly in connection with the warning services.

Weekly telegrams are received from April to October from the Director, Royal Alfred Observatory, Mauritius. These telegrams give valuable information of the weather conditions in the Indian Ocean, and the department is indebted to this observatory for the punctual transmission of the information.

The department is greatly indebted for important information on meteorological conditions prevailing before and during the southwest monsoon to the Controller, Physical Department, Cairo ; the Directors of the Observatories at Buenos Ayres and Santiago ; the Astronomer Royal, Cape Town ; Director L'Observatoire Physique Central, Leningrad ; the Secretary, Friends' Industrial Mission, Benani Pemba, Zanzibar ; the Director, Department of Agriculture, Zanzibar ; the Director, British East African Meteorological Service ; the Port Officer, Seychelles ; the Commonwealth Meteorologist, Melbourne ; Director of Agriculture, Salisbury, Rhodesia ; Chief of the Weather Bureau, Washington. Thanks of the department are due to the Director, Koninklijk Magnetischund Meteorologisch Observatorium, Batavia, for similar information and also for the daily weather telegrams from Sabang in Sumatra.

Thanks are due to the Marine Superintendents of the British India Steam Navigation Company, the Scindia Steam Navigation Company, the Asiatic Steam Navigation Company, and the Burma Oil Company for continuing the arrangement under which many captains of their fleets send weather logs to this Department. The Principal Officer, Mercantile Marine Department, Bombay, the Deputy Conservator of the Port of

Bombay, the Deputy Conservator of the Port of Calcutta and the Flag Officer Commanding and Director, Royal Indian Navy, have been willing helpers of this department, for which it is grateful to them.

The department is indebted to the Government of His Exalted Highness the Nizam of Hyderabad and to the Government of His Highness the Maharaja of Mysore for their co-operation by regular collection of pilot balloon data at the Nizamiah Observatory, Begumpet (Hyderabad), and the Central Observatory, Bangalore, respectively, as also for their assistance in the recovery of sounding balloon instruments found in their territories. The thanks of the department are due to the Royal Air Force for their valuable assistance in collecting upper air data from aeroplanes at Quetta, Peshawar and Karachi. The department is also grateful to the Government of Travancore for their co-operation in the regular collection of pilot balloon data at Trivandrum.

The India Meteorological Department is greatly indebted to the Imperial Council of Agricultural Research for inaugurating work on Agricultural Meteorology and to the Directors of Agriculture and Institutions in the different provinces and States and to the various agricultural workers in the country for their valuable co-operation. The department is also very grateful to the Principal of the Agricultural College, Poona, for the facilities given for experimental work at the College farm.

Thanks are due to the Eastern Telegraph Company for charging this department half the usual rates for the transmission of South American Weather telegrams. Thanks are also due to the various pilots of the Imperial and Indian Trans-Continental Airways, Tata Sons, Limited, and to the Dutch and French Air Services for the supply of weather logs to this department ; to the various ships' officers, who sent their marine weather logs direct to this department ; to the Superintendent of the Colombo Observatory for the most useful help he has rendered from time to time in connection with storm warning work and for the useful data of Ceylon stations supplied to this department.

POONA :
The 19th July, 1935.

C. W. B. NORMAND,
Director General of Observatories.

APPENDIX A.

The Staff of the India Meteorological Department as it stood on 31st March 1935.

METEOROLOGICAL OFFICE, POONA.

Director General of Observatories.

C. W. B. Normand, M.A., D.Sc. (Edin.).

General Section.

Meteorologist	S. K. Banerji, M.Sc., D.Sc. (Cal.).
Assistant Meteorologist	S. S. Lal, M.Sc. (Lucknow and Lond.), D.I.C. (London), A.Inst.P., F.R.Met. Soc. (temporary).
Superintendent	C. P. Venkataramier, M.A. (Madras).
Assistants	5
Stenographers	4
Cashier	1
Clerks and typist	11

Weather Section.

Meteorologist	S. Basu, M.Sc. (Allahabad).
Assistant Meteorologist	B. N. Sreenivasaiah, M.Sc. (Cal.).
Assistants	2
Clerks and tabulators	12
Draftsmen	5

Observatories Section.

Assistant Meteorologist	Barkat Ali, B.A., M.Sc. (Punjab).
Assistants	2
Inspector of Observatories	1
Clerks	2
Current Weather Observers	8 (stationed at outstations).

Marine Section.

Meteorologist	V. V. Sohoni, B.A. (Hons.), M.Sc. (Bombay).
Assistant	1
Clerks	2

Instrument Section.

Meteorologist	J. M. Sil, B.A. (Cal.), B.Sc. (Engg.), (Boston Tech.).
Assistant Meteorologist	P. R. Krishna Rao, B.Sc. (Mysore).
Assistants	2
Clerks	5
Draftsman	1
Senior Observers	3
Junior Observer	1
Storekeeper	1
Chief Mechanic	1
Mechanics (temporary)	3
Carpenter (temporary)	1

Upper Air Section.

Meteorologist	K. R. Ramanathan, M.A., D.Sc. (Madras).
Assistant Meteorologist	K. Das, M.Sc. (Punjab), Ph.D. (Lond.).
Assistant	1
Clerks	2
Senior Observer	1
Junior Observers	4

Statistical Section and Library.

Meteorologist	S. R. Savur, M.A. (Madras), Ph.D. (Lond.).
Assistant Meteorologist	V. Doraiswamy Iyer, B.A. (Madras), F.R.Met.Soc.
Assistants	3
Librarian	1
Clerks	15
Draftsmen	3

Agricultural Meteorology Branch.

Junior Agricultural Meteorologist	L. A. Ramdas, M.A., Ph.D. (Calcutta).
Professional Assistant	R. J. Kalamkar, B.Sc. (Nagpur), B.Ag. (Nagpur), Ph.D. (London).
Senior Observers	2
Junior Computors	3

Upper Air Observatory, Agra.

Meteorologist-in-charge	G. Chatterjee, M.Sc. (Calcutta).
Meteorologist	N. K. Sur, D.Sc. (Allahabad).

Upper Air Observatory, Agra—*contd.*

Assistant Meteoro'ogists	S. L. Malurkar, B.Sc. (Mysore), M.Sc. (Cantab.).
	S. P. Venkiteshwaran, B.A. (Hons.) (Madras) (temporary).
	S. K. Das, M.Sc. (Dacca and London), D.I.C. (Lond.), F.R.Met.Soc. (Lond.) (Offg.).
Superintendent	Babu Ram Samnol.
Mechanical Assistant	Chain Sukh.
Chief Observer	1
Chief Computor	1
Foreman	1
Clerks or Observers	41 (at Agra).
Clerks or Observers	66 (outstation staff).
Mechanics (temporary)	10
Clerks and Observers (temporary)	3
Enginemen	2

Colaba and Alibag Observatories, Bombay.

Meteorologist	S. C. Roy, M.Sc. (Cal.), D.Sc. (London).

At Colaba.

Head Clerk	D. L. Choudhury, M.Sc. (Cal.) (on probation).
First Assistant	1
Senior Upper Air Observer	1
Observers	6
Cashier.	1
Marine Clerk	1
Typist and Stenographer	1
Junior Upper Air Observer	1

At Alibag.

Observers	2

Alipore Observatory and Meteorological Office, Calcutta.

Meteorologist	S. N. Sen, M.Sc. (Cal. and London), Ph.D. (London).
Assistant Meteorologists	B. N. Desai, M.Sc. (Bombay), Ph.D. (Edin.), B.A., LL.B. (Bombay), F.R.S.E.
	C. Ramaswamy, M.A. (Hons.) (Madras) (Offg.).
	N. P. Chatterji, M.Sc. (Cal.) (Offg.).

Alipore Observatory and Meteorological Office, Calcutta—*contd.*

Professional Assistant	B. B. Roy, M.Sc. (Offg.).
Superintendent	T. N. Mitra, B.A., B.L.
Chief Observer	R. Bakshi, M.Sc. (Offg.).
Meteorological Assistants	3 (On Poona Establishment, posted at auxiliary centres).
Inspector of Observatories	1
Clerks (Upper division)	5
Stenographer	1
Senior Observers	2
Clerks and Observers (Lower division)	25
Clerks (Routine division)	5
Junior Observers	2
Observers (at outstations)	5
Printer (Press staff)	1

Meteorological Office, Karachi.

Meteorologist	S. K. Pramanik, M.Sc. (Lucknow), D.I.C., Ph.D. (London).
Assistant Meteorologists	B. K. Roy, M.Sc. (Calcutta).
	S. Mal, M.Sc. (Benares), D.I.C., Ph.D. (Lond.).
Professional Assistant	H. R. Puri, M.Sc. (Punjab).
Meteorological Assistant	1 (On Poona Establishment, posted at *auxiliary centre at Jodhpur).*
Chief Observer	1
Head Clerk	1
Inspector of Observatories	1
Stenographer	1
Senior Clerks or Observers	4
Clerks or Observers	9
Clerks	5
Junior Clerks or Observers	2
Observers (at outstations)	3
Clerk (temporary)	1

Solar Physics Observatory, Kodaikanal.

Director	T. Royds, D.Sc. (London), F.R.A.S.
Assistant Director	A. L. Narayan, M.A., D.Sc. (Madras), F.I.P.
Assistants	3
Recorders	4
Mechanic	1
Book-binder	1

Meteorological Office, No. 3 (Indian) Wing, R. A. F., Quetta.

Meteorologist	A. K. Roy., B.Sc. (Cal.), B.A. (Oxon.) (temporary).
Senior Clerk	1
Junior Clerks	4

Meteorological Office, No. 1 (Indian) Group Headquarters, R. A. F., Peshawar.

Meteorological Officer (R. A. F.)	F./Lt. R. G. Veryard, B.Sc.
Senior Clerk	1
Junior Clerks and Observers	4

Lahore Observatory.

Chief Observer	1
Clerks or Observers	2
Junior Observer (temporary)	1

Madras Observatory.

Assistant-in-charge	1
Senior Observer	1
Junior Observers	2

Officers on leave.

B. N. Banerji, M.Sc. (Allahabad), Ph.D. (Cantab.).

K. J. Kabraji, B.A. (Hons.), B.Sc. (Bombay), M.Sc., Ph.D. (London).

A. K. Das, M.Sc. (Cal.), D.Sc. (Paris).

APPENDIX B.

PUBLICATIONS.

The following departmental publications were issued or sent to press during the year :—

I.—*Periodical.*

1. Daily Weather Reports—
   - i. Indian Daily Weather Report.
   - ii. Calcutta Daily Weather Report.
   - iii. Karachi Daily Weather Report.
2. Weekly Weather Report.
3. India Weather Review, Monthly Weather Report.
4. India Weather Review, 1933, in five parts—
   - i. Introduction.
   - ii. Part A.—Summary of Weather and Rainfall and Tables.
   - iii. Part B.—Snowfall.
   - iv. Part C.—Storms and Depressions.
   - v. Part D.—Seismic Records.
5. Daily Rainfall of India for 1932.
6. Monthly Rainfall of India for 1932.
7. Upper Air Data, 1933, in 14 parts—
   - i. Parts 1—2. Pilot Balloon and Aeroplane Data for January and February.
8. Seasonal Memoranda—
   - i. Statement of the rainfall and snowfall of North-West India in January, February and March 1934 and a comparison of the seasonal forecast with the actual precipitation.
   - ii. Memorandum regarding the probable amount of monsoon rainfall in 1934.
   - iii. Memorandum on the rainfall of June and July and the probable amount during August and September 1934.
   - iv. Statement of the actual rainfall in the monsoon season, June to September 1934, and a comparison of the forecasts with the actual rainfall.
9. Magnetic, Meteorological and Seismographic Observations made at the Government Observatories, Bombay and Alibag, in the year 1932.
10. Report on the Administration of the Meteorological Department of the Government of India in 1933-34.
11. Annual Report of the Kodaikanal Observatory, 1934.

II.—*Occasional.*

1. Scientific Notes—

Vol. V—

No. 60.—A study of Horizontal Atmospheric Visibility at Bangalore by A. Anantapadmanabha Rao, B.A.

Vol. VI—

No. 61.—Evaporation in India calculated from other Meteorological Factors by P. K. Raman, B.A. and V. Satakopan, M.A.

No. 62.—The Distribution of Temperature in the Upper Levels of a Depression originating in the Bay of Bengal during the Indian Southwest Monsoon by N. K. Sur.

No. 63.—Wind Data for Wind Mills by V. Doraiswamy Iyer, B.A.

No. 64.—On the Thermal Structure of Cumuliform Clouds by Flt./Lt. R. G. Veryard, B.Sc., R.A.F.

No. 65.—Thermal Structure of the Upper Air over a depression during the Indian Southwest Monsoon by N. K. Sur.

No. 66.—Normal Monthly Percentage Frequencies of Upper Winds at 4, 6, 8 and 10 kms. above sea-level obtained from Pilot Balloon Ascents—Departmental.

Kodaikanal Observatory Bulletins—

No. CIV.—Summary of Prominence Observations for the second half of the year 1933.

No. CV.—Summary of Prominence Observations for the first half of the year 1934.

3. International Cloud Atlas of Tropical Clouds, English translation (for Departmental use).

4. Instructions to Observers, 2nd edition.

The following papers or notes were contributed to extra-departmental journals :—

1. Banerji, S. K.—

The North Bihar Earthquake of January 15, 1934,—Current Science, Vol. III, 1935, pp. 409—412.

2. Basu, S. and Desai, B. N.—

A discussion on the structure of the Inner Zone of some Indian Cyclones—Ger. Beit. zur Geophysik, Band 42, 1934, pp. 353—364.

3. Desai, B. N.—

Colloids in the Atmosphere,—Journal of the Bombay University, Vol. III, 1934, pp. 195—218.

Importance of dialysis in the study of Colloids,—Journal of the Bombay University, Vol. II, 1933, p. 255.

Changes in the charge on Colloidal particles during dialysis of solutions, Current Science, Vol. II, 1934, p. 473.

—— and Collaborators.—

Inhibitive power of Agar,—Current Science, Vol. III, 1934, p. 172.

—— and Naik, B. M.—

Inhibitive power of Gelatine,—Journal of the Bombay University, Vol. II, 1933, p. 90.

—— Desai, H. N. and Naik, D. B.—

Conductivity Measurements of some Chlorides, Iodides and Nitrates of Alkalies and Alkaline earths in water and methyl and ethyl and n. propyl alcohols,—Indian Journal of Physics, Vol. VIII, 1934, pp. 323—340.

—— Desai, S. N. and Naik, D. B.—

Viscosity of moderately and highly concentrated solutions of some electrolites in water, methyl, ethyl and n. propyl alcohols and a discussion of relation between conductunce and fluidity,—Journal of the Bombay University, Vol. III, 1934, p. 109.

—— Joshi, C. B. and Barve, P. M.—

Changes in charge, Conductivity stability and composition of Colloidal arsenious sulphide on exposure to light,—Current Science, Vol. III, 1934, p. 105.

4. Doraiswamy Iyer, V.—

Typhoons and Indian Weather,—Current Science, Vol. III, 1935, pp. 308-309.

5. Kalamkar, R. J.—

Micro-climatology in relation to crops,—Current Science, Vol. III, 1934, pp. 80-81.

6. Malurkar, S. L.—

Ellipsoidal wave functions,—Indian Journal of Physics, Vol. IX, 1934, pp. 45—80.

Continued fractions associated with Ellipsoidal wave functions,—Indian Journal of Physics, Vol. IX, 1934, pp. 251—254.

Ellipsoidal wave functions,—Journal of the Bombay University, Vol. III, 1934, pp. 16—20.

Effect of Radiation on the transmission of discontinuity,—Pro. of the Indian Academy of Sciences, Vol. I, 1935, Section A, pp. 454—456.

7. Ramanathan, K. R.—

The Stratosphere balloon and its use in Scientific Research,—Current Science, Vol. III, 1934, pp. 183-184.

——— and Ramdas, L. A.—

The Transparency of the atmosphere in the Ultra-Violet and a possible means of extending the solar spectrum in the region 2200—2000 A. U.—Proceedings of the Indian Academy of Sciences, Vol. I, 1934, Section A, pp. 308—314.

8. Ramdas, L. A.—

Micro-climatology,—Current Science, Vol. II, 1934, pp. 445—447.
Frost Hazard in India,—Current Science, Vol. III, 1935, pp. 325—333.

——— Kalamkar, R. J. and Gadre, K. M.—

Studies in Micro-climatology,—Part I, Indian Journal of Agricultural Science, Vol. IV, 1934, pp. 451—467.

Studies in Micro-climatology,—Part II, Indian Journal of Agricultural Science, Vol. V, 1935, pp. 1—11.

——— and Katti, M. S.—

The variation of Moisture in the surface layer of the soil in relation to the diurnal variation of Meteorological Factors,—Current Science, Vol. III, 1934, pp. 24-25.

Preliminary studies on soil moisture in relation to Moisture in the surface layers of the Atmosphere during the clear season at Poona,—Indian Journal of Agricultural Science, Vol. IV, 1934, pp. 923—937.

—— and Dravid, R. K.—

Soil Temperatures,—Current Science, Vol. III, 1934, pp. 266-267.

9. Roy, S. C.—

Earthquake Problems in India,—Special Earthquake Number of the Bombay Chronicle and Sentinel, 1934 (March).

Seismometric Study of the North Bihar Earthquake of January 15, 1934, and its aftershocks,—Current Science, Vol. III, 1935, pp. 298—300.

The Cold Wave of January 1935,—Current Science, Vol. III, 1935, pp. 334-335.

10. Savur, S. R.—Elimination of bias due to selection,—Current Science, Vol. III, 1934, pp. 152—153.

11. Sen, S. N.—

The Meteorological aspects of the " Rains of Fishes ",—Journal and Pro. of the Asiatic Society of Bengal, New Series, Vol. XXIX, 1933, pp. 111—116.

—— and Chatterjee, N. P.—

Himalayan Meteorology, Everest, 1933, Section II, Chapter IX.

12. Unakar, M. V.—

Meteorology in the Rigveda,—Journal of the Bombay Branch, Royal Asiatic Society, New Series, Vol. 10, 1934, pp. 38—57.

13. Veryard, R. G.—

Scent and the Weather (published by the Masters of Foxhounds Association in India), 1935, pp. 1—33.

Anti-Solar Rays,—Meteorological Magazine, Vol. LXIX, 1934, p. 216.

Dust-Devils,—Meteorological Magazine, Vol. LXIX, 1934, p. 268.

APPENDIX C,

Classification of Observatories, etc.

Meteorological or Weather Observatories.—The functions of a meteorological or weather observatory is to record the observations of such elements as can be recorded by an observer with the help of instruments on the ground (as distinct from upper air observations obtained by means of balloons, etc.). Observatories where the staff is provided and paid for by other agencies, *e.g.*, Indian States, are called non-departmental although instruments are supplied by the Meteorological Department. These surface observatories are classified according to the number of observations per day and the number and kind of instruments to be read. Thus :—

First Class.—Such observatories are furnished with autographic instruments for continuously recording pressure, temperature, humidity, wind direction and velocity, and rainfall, in addition to instruments, read by eye. It may also undertake special observations (*e.g.*, on atmospheric electricity). The staff required varies from two part-time observers to about four full-time observers according to the amount of special work and of computation and tabulation of data.

Second Class.—At second class weather observatories observations are taken twice daily and usually telegraphed to one or more forecast centres. The existing standard times of observation in India are 8 hrs. (Local Time) and 17 hrs. (Indian Standard Time)*, the observations being made by a part-time observer on Rs. 25 per mensem.

Third Class.—At these observatories readings are taken daily at 8 hrs. and sent by telegram daily or by post at the end of each month to one or more forecast centres. At each observatory of this type there is one part-time observer on Rs. 15 a month.

Fourth Class.—Observations (*a*) of temperature, wind and rainfall only or (*b*) of temperature and rainfall only are recorded at Class IV observatories. The staff of a 4th class observatory is one part-time observer on pay not exceeding Rs. 12 a month.

Fifth Class Weather Observatories.—At these observatories part-time observers on Rs. 5 p. m. record and telegraph rainfall. At some of these observatories certain non-instrumental observations are also taken and telegraphed in the "Brief Weather Code".

Non-Instrumental Observatories.—Observatories of this kind do not possess any instruments but an observer records visual observations of weather phenomena. This class includes the type of observatory called the *current weather station* which is established on or near an air route for recording local current weather for airmen. At such a station observations of past and present weather, visibility, cloud, wind direction and force are recorded at certain fixed times daily and at other hours on request : the usual staff at a current weather station is one whole-time observer.

Pilot Balloon Observatories.—At such observatories pilot balloons (*i.e.*, balloons without attached instruments) are released and observed through special theodolites for the determination of wind directions and velocities at various heights in the free atmosphere. The minimum staff is two full-time observers for one balloon flight per day and three full-time observers and a balloon maker for two balloon flights per day.

Upper Air Observatories.—Upper Air Observatories undertake observations for upper winds, and of upper air temperatures, humidities and pressures up to heights of about 15—20 miles, by means of sounding balloons (*i.e.*, balloons with self-recording instruments attached).

Air Observatories.—Air observatories are those to which Royal Air Force supply aeroplane data of temperatures and humidities up to heights of 2 or 3 miles.

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* Surface observations at Persian stations are taken at 4 and 12 hours Greenwich Mean Time. (Add 5½ hours to convert to Indian Standard Time.)

Magnetic Observatory.—Such an observatory is equipped with instruments for continuously recording the principal magnetic elements.

Seismological Stations.—These stations are equipped with one or more continuously recording seismographs.

Time Observatories.—These are equipped with instruments for the determination of time from observations of sun and stars and from European wireless time-signals.

Solar Physics Observatory.—The Department has an observatory at Kodaikanal equipped with photo-heliographs, spectro-heliographs, etc., where special work on solar physics is done.

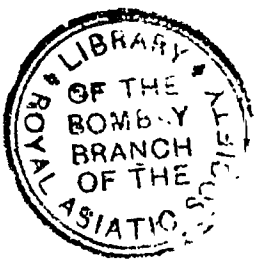
Auxiliary Centre.—A centre where a Professional or Meteorological Assistant receives copies of weather reports from the forecasting centres for transmission and elucidation to pilots adding his own remarks or conclusions about the local weather situation if and when necessary.

Forecast Centres.—At which weather observations are collected by telegrams from a number of stations in order to form the basis of weather reports and forecasts issued therefrom. These may be (*a*) Main Centres, serving a large area for general purposes, or (*b*) Regional Centres, serving more limited areas for special purposes.

GIPD—110 DG of Obs—19-10-3—480.

NO—RM/36.

Report on the Administration of the Meteorological Department of the Government of India in 1935-36.



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1936.

Price As. 14 or 1s. 6d.

List of Agents in India from whom Government of India Publications are available.

(a) PROVINCIAL GOVERNMENT BOOK DEPOTS.

MADRAS:—Superintendent, Government Press, Mount Road, Madras.

BOMBAY:—Superintendent, Government Printing and Stationery, Queen's Road, Bombay.

SIND:—Manager, Sind Government Book Depot, Karachi (Sadar).

UNITED PROVINCES:—Superintendent, Government Press, Allahabad.

PUNJAB:—Superintendent, Government Printing, Punjab, Lahore.

BURMA:—Superintendent, Government Printing, Burma, Rangoon.

CENTRAL PROVINCES:—Superintendent, Government Printing, Central Provinces, Nagpur.

ASSAM:—Superintendent, Assam Secretariat Press, Shillong.

BIHAR AND ORISSA:—Superintendent, Government Printing, P. O. Gulzarbagh, Patna.

NORTH-WEST FRONTIER PROVINCE:—Manager, Government Printing and Stationery, Peshawar.

(b) PRIVATE BOOK-SELLERS.

Advani Brothers, P. O. Box 100, Cawnpore.
Aero Stores, Karachi.*
Albert Library, Dacca.
Banerjee & Bros., Ranchi, Messrs. G.
Banthiya & Co., Ltd., Station Road, Ajmer.
Bengal Flying Club, Dum Dum Cantt.*
Bhawnani & Sons, New Delhi.
Book Company, Calcutta.
Booklover's Resort, Taikad, Trivandrum, South India.
Burma Book Club, Ltd., Rangoon.
Butterworth & Co. (India), Ltd., Calcutta.
Calcutta Book Agency, 16-1, Shama Charan Dey Street, Calcutta.
Chatterjee & Co., 3, Bacharam Chatterjee Lane, Calcutta.
Chukervertty, Chatterjee & Co., Ltd., 13, College Square, Calcutta.
City Book Co., Madras.
City Book House, Meston Road, Cawnpore.
Commercial Book Co., Lahore.
Das Gupta & Co., 54/3, College Street, Calcutta.
Deccan Book Stall, Poona 4.
Delhi and U. P. Flying Club, Ltd., Delhi.*
English Book Depot, Ferozepore.
English Book Depot, Taj Road, Agra, and Saddar Bazar, Jhansi.
English Book Depot, Bank Road, Ambala Cantonment and Kasauli.
English Bookstall, Karachi.
Faqir Chand Marwah, Peshawar Cantonment.
Fono Book Agency, Simla.
Gaya Prasad & Sons, Agra.
Grantha Mandir, Cuttack.
Higginbothams, Madras.
Hindu Library, 137/F, Balaram De Street, Calcutta.
Hyderabad Book Depot, Chaderghat, Hyderabad (Deccan).
Imperial Book Depot and Press, near Jama Masjid (Machhliwalan), Delhi.
Indian Army Book Depot, Dayalbagh, Agra.
Indian Army Book Depot, Jullundur City and Daryaganj, Delhi.
Indian Book Shop, Benares City.
Indian School Supply Depot, Central Avenue South, P. O. Dharamtala, Calcutta.
Insurance Publicity Co., Ltd., Lahore.
International Book Service, Poona 4.
Jacques & Co., Kamptee Road, Nagpur, Messrs. Neston.
Jaina & Bros., Mori Gate, Delhi, and Connaught Place, New Delhi, Messrs. J. M.
James Murray & Co., 12, Govt. Place, Calcutta (for Meteorological publications only).
Kali Charan & Co., Municipal Market, Calcutta.
Kamala Book Depot, 15, College Square, Calcutta.
Kamala Book Stores, Bankipore, Patna.
Karnataka Publishing House, Bangalore City.
Keale & Co., Karachi.
Kitabistan, 17-A, City Road, Allahabad.
Krishnaswami & Co., Teppakulam P. O., Trichinopoly Fort, Messrs. S.
Lahiri & Co., Calcutta, Messrs. S. K.
Law Printing House, 11, Mount Road, Madras.
Law Publishing Co., Mylapore, Madras.
Lawrence and Mayo, Ltd., Bombay (for Meteorological publications only).
Local Self-Govt. Institute, Bombay.
London Book Co. (India), Arbab Road, Peshawar, Murree, Nowshera, Rawalpindi.
London Book Depot, B. I. Bazar, Bareilly, U. P.
Messrs. U. P. Malhotra & Co., Post Box No. 94, Lahore.
Minarva Book Shop, Anarkali Street, Lahore.
Modern Book Depot, Bazar Road, Sialkot Cantonment.
Mohanlal Dossabhai Shah, Rajkot.
Motilal Banarsi Das, Oriental Booksellers, Saidmitha Street, Lahore.
Nandkishore & Bros., Chowk, Benares City.
Nateson & Co., Publishers, George Town, Madras, Messrs. G. A.
New Book Co., "Kitab Mahal," 192, Hornby Road, Bombay.
Newman & Co., Ltd., Calcutta, Messrs. W.
North India Christian Tract and Book Society, 18, Clive Road, Allahabad.
Oriental Book Supplying Agency, 15, Shukrawar, Poona City.
Oxford Book and Stationery Company, Delhi, Lahore, Simla, Meerut and Calcutta.
Parikh & Co., Baroda, Messrs. B.
Pioneer Book Supply Co., 20, Shib Narayan Das Lane, Calcutta, and 219, Cloth Market, Delhi.
Popular Book Depot, Grant Road, Bombay.
Punjab Religious Book Society, Lahore.
Raghunath Prasad & Sons, Patna City.
Rama Krishna & Sons, Booksellers, Anarkali, Lahore.
Ram Krishna Bros., Opposite Bisnrambag, Poona City.
Ram Narain Lal, Katra, Allahabad.
Ramesh Book Depot and Stationery Mart, Kashmere Gate, Delhi.
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Ray Chowdhury & Co., 119, Ashutosh Mukherjee Road, Bhawanipur, Calcutta.
Rochouse & Sons, Madras.
Roy Chowdhury & Co., 11, College Square, Calcutta, Messrs. N. M.
Sampson William & Co., 127-B, The Mall, Cawnpore.
Sarcar & Sons, 15, College Square, Calcutta, Messrs. M. C.
Sarkar & Co., Ltd., 18, Shama Charan De Street, and 8/2, Hastings Street, Calcutta, Messrs. P. C.
Scientific Publishing Co., 9, Taltola Lane, Calcutta.
Seshachalam & Co., Masulipatam, Messrs. M.
Shivji & Co., P. O. Chauliaganj, Cuttack.
Shri Shankar Karnataka Pustaka Bhandara, Malamuddi, Dharwar.
S. P. Bookstall, 21, Budhwar, Poona.
Standard Bookstall, Karachi.
Standard Bookstall, Quetta.
Standard Book Depot, Lahore, Dalhousie and Delhi.
Standard Law Book Society, 5, Hastings Street, Calcutta.
Standard Literature Company, Ltd., Calcutta.
Students' Popular Depot, Kacheri Road, Lahore.
Surat and District Trading Society, Surat.
Taraporevala Sons & Co., Bombay, Messrs. D. B.
Thacker & Co., Ltd., Bombay.
Thacker, Spink & Co., Ltd., Calcutta and Simla.
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Union Stores, Indore City.
University Book Agency, Kacheri Road, Lahore.
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Report on the Administration of the Meteorological Department of the Government of India in 1935-36.

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FIG. 1.

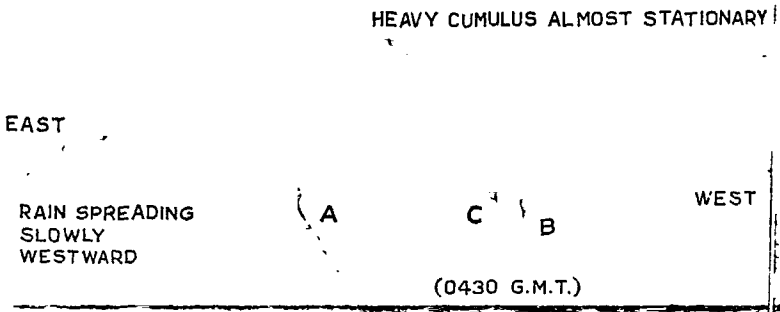


FIG. 2.

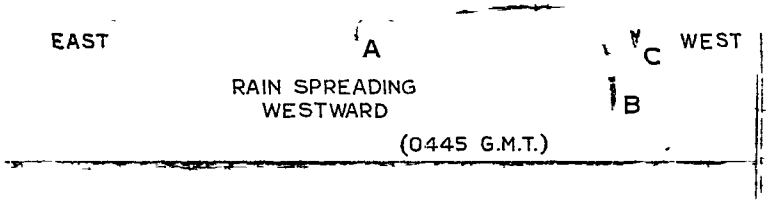
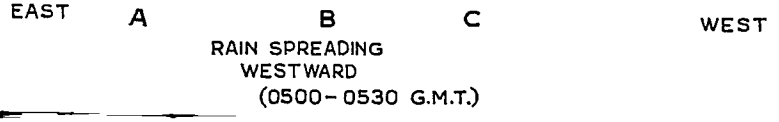


FIG. 3.



Drawings of three "water-spouts" A, B & C, under a heavy mass of cumulus cloud as observed on 14th February 1936 at 0430 G.M.T. by the 3rd Officer of S. S. Sirsa (B. I. S. N. Co. Ltd.) Calcutta to Rangoon, (Lat. 19° 10′ N. Long. 90° 30′ E.)

Fig. 1. 0430 G.M.T. A was well defined and reached the water; B was broader but incomplete. Both appeared to have a clear core and well defined outer surfaces. C was very narrow possibly farther than B moving quickly towards the west.

Fig. 2. 0445 G.M.T. A broke while B became narrow, its end extended quickly downward and reached the surface of the water. C became more defined. The vapour like disturbance set up by B on the surface of the sea gradually gained altitude and appeared to envelope B.

Fig. 3. 0500-0530 G.M.T. At 0500 hrs. B disappeared, while C continued to become more defined, and reached the surface of the sea; maintaining its shape and position until 0530 hrs., when it was overtaken by the rain spreading from the east, and disappeared.

The first appearance of the phenomenon was noticed to the southeast of the ship at a distance of about 12 miles.

Signature and Rank of Observing Officer.

Signature of Captain.

WATERSPOUTS OBSERVED ON FEBRUARY 14, 1936, OVER THE NORTH BAY OF BENGAL.

G. P. Z. O. Poona, 1936.

Report on the Administration of the Meteorological Department of the Government of India in 1935-36.

Chief Features of the Year.

1. In this part of the report an attempt is made to summarise the chief features of the work of this department during the year. Fuller details are given in the subsequent chapters. The salient points were (*a*) the development of services in connection with aviation, (*b*) the realisation that the development of the Empire Air Services and other branches of aviation in India will necessitate in the immediate future a considerable increase of such meteorological services, (*c*) an indication how through economies now being achieved in the normal telegraphic expenditure the cost of development in this direction may in part at least be met, and (*d*) the increased interest that India is required to take in International meteorology.

Services to Aviation.

2. The routine system of transmission of weather reports along the trans-India route, Karachi-Victoria Point, which was introduced in 1934, worked satisfactorily during the year. Under this system, the route is divided into six sections with terminal points at Karachi, Jodhpur, Allahabad, Calcutta, Akyab, Rangoon and Victoria Point respectively. Forecasts are issued in the evening by wireless for each section of the route; and aerodromes display them on notice-boards. These forecasts are supplemented or amended, if necessary, at noon each day by brief reports covering the afternoon hours. The diffusion of the latest news about upper winds and "current weather," *i.e.*, information about cloud, visibility, rain, ground wind, etc., has been similarly placed on a routine basis. There are also arrangements for the supply of special current weather reports at any time to aircraft in flight on request as well as for warnings about such phenomena as are considered dangerous to flying. The method of supplying weather information either in person or through landline telegram to each aircraft separately is, however, still in vogue on other routes, as the air traffic is not yet sufficiently heavy to make the introduction of the 'routine' system necessary. Moreover, on these routes W/T facilities do not yet exist and the machines are not generally fitted with wireless.

3. The main criticism of the routine system from pilots referred to the omission of information about cloud-height in the brief current weather reports. The International Code (1929) for the tropics in respect of current weather reports does not include cloud-height. The revised International Code (1935) includes this information, and, though it is not to come into general operation until 1937, it has been adopted in India from 1st March 1936 in order to meet the demand of airmen. The introduction of the International Q Code during the year offered another convenient method of exchanging weather information by wireless in brief form between aircraft and observatories.

4. On account of the diversion of the Karachi-Lahore route *via* Jacobabad, the pilot balloon station at Sukkur was shifted to Jacobabad. The long-contemplated shift of the pilot balloon station from Muscat to Sharjah also was effected during the year as soon as accommodation for the staff was completed in the Fort of Sharjah. The establishment of a W/T station at Tavoy led to the shifting of the Upper Air Observatory from Silchar to Tavoy. Steps were taken to start a non-instrumental observatory at Gauchar in connection with the Hardwar-Gauchar Air Service. The department arranged for the regular supply of weather reports to the newly inaugurated Bombay-Trivandrum air mail service, operated by Tata Sons, Ltd. The increased frequency in flying was reflected in a 50 per cent. increase in the number of weather reports and forecasts issued to airmen by the various forecasting centres.

5. Under the Capital Expenditure scheme for the development of air-routes in India, which was approved by Government during the previous year, offices, observatories and residential quarters are to be constructed at aerodromes on the trans-India air-route as well as an additional office building and some residential quarters at the Upper Air Observatory, Agra. The progress made during the year involved the settlement of many details of siting and layout in co-ordination with the programme of the department of Civil Aviation, and the examination of plans and estimates for most of the buildings at these places.

Possible developments of services to aviation.

6. There were also projects to be prepared in connection with the Empire Air Development Scheme, which is expected to come into operation during the next two years. The Empire Air Services, on the main trans-India route as well as those on the feeder routes, Karachi-Colombo and Karachi-Lahore are planned to operate about five times every week both ways and there will be night flying between Karachi and Calcutta. The problem of providing the essential meteorological reports cheaply under the changed conditions received the most careful consideration. At important stations along the route it will probably be necessary to maintain a service throughout the 24 hours and at all intermediate stations for 15 hours or more. The development will involve sending up illuminated balloons for the measurement of upper winds at night, search-lights for determination of cloud heights, special arrangements for measurements of visibility at night, and provision of extra staff for night attendance. Night-flying involves more or less blind flying, in which airmen need all the help they can get to navigate their machines safely, and in countries where night flying has developed to a considerable extent, such as Germany and the United States of America, there are meteorological stations on the routes 50 or 60 miles apart; in India, however, financial considerations will permit stations only at intervals of about 300 miles.

Economies that may help to meet the cost of developments.

7. Can money be found from other items in the normal budget of the department to pay for the newer needs? This was a question that engaged much attention during the year. On account of

cheaper telegrams and by taking full advantage of aeronautical wireless stations for the exchange of weather telegrams between aerodromes, the department was able to show a permanent saving of more than half a lakh annually in its normal telegraphic expenditure. The introduction of the 8-words telegram seems to open out another road to effect savings; this is still being examined; and the possible savings which may result will be reserved, it is hoped, for some of the newer, more modern requirements.

General Activities.

8. Besides the activities on behalf of aviation mentioned above, the normal activities of the department were continued as efficiently as possible. Warnings for cyclones, storms, depressions, thunder-squalls, heavy rain and low temperatures were issued as usual from Poona and Calcutta to shipping in the Arabian Sea and the Bay of Bengal, to sea-ports around the Indian coasts, river-ports in Bengal and numerous Government officers in railway, public works, agricultural or other departments. The time-signal work at Calcutta and Bombay, solar observations at Kodaikanal, seismological and magnetic observations at Bombay, compilation and tabulation of climatological data, exploration of the upper air by pilot balloon and sounding balloon continued to be carried on as in previous years. Fifteen first class and 253 second and third class observatories scattered over India, Burma, Port Blair, Iran and Arabia were maintained and about 134 of these were inspected.

9. The disastrous earthquake, which occurred at Quetta, on 31st May 1935, demolished the Meteorological Office and Observers' quarters; the Meteorologist suffered a tragic family loss. The Meteorological Office was temporarily transferred to Karachi. The pilot balloon station at Quetta was temporarily transferred to Dera Ismail Khan and a temporary surface observatory was opened at Quetta as soon as conditions permitted this to be done.

Empire and International Meteorological Conferences.

10. The Director-General of Observatories attended on deputation the meeting of the Empire Meteorological Conference held in London from August 12 to 21, 1935. The Empire Meteorological Conference was the third of the series and as many as 25 different parts of the Empire were represented at the meetings. The Conference offered an invaluable opportunity for personal contacts between Directors from practically every quarter of the Empire, giving them an opportunity to exchange experiences and pool information. At this conference discussions were mainly directed to the practical application of meteorology to commercial aviation, agriculture, the defence services and navigation at sea. The Director-General also attended the International Meteorological Conference at Warsaw from 6th to 13th September 1935, as well as many of the meetings of the various expert commissions which preceded the Conference. Most of the discussions concerned arrangements which aim at better collaboration and uniformity in meteorological work in different countries. Some of the items

accepted at the conference and which are of immediate concern to India are :—

(1) Use of International Weather Symbols and uniform method of charting.

(2) An amended form of the International Weather Code used on land in tropical regions.

(3) An amended form of the International Weather Code used by ships in tropical regions.

(4) A new classification of meteorological literature to bring it into line with the International Decimal Classification.

(5) Use of radio sondes in upper air research.

(6) A world-wide scheme of issue of collective synoptic broadcasts in order to fill in the gaps in the existing inter-continental issues.

(7) A world-wide scheme to broadcast climatological data of selected stations once a month.

Daily issue of data for other countries and shipping.

11. Air traffic has not only increased in frequency, it has also become regular between India and Siam, Malaya and Indo-China. The exchange of meteorological data with these and other countries has therefore become a problem of considerable importance. Government sanctioned the transmission to Siam of the data of three Indian stations daily by special telegram addressed to Bangkok. This, however, does not benefit Malaya or Indo-China; and the system of exchange will not be satisfactory until the synoptic data for Burma are broadcast regularly from a sufficiently powerful wireless station. Fortunately, short-wave aeronautical stations are being established at Rangoon and Calcutta and it is expected that, when these are completed, the problem of exchanging synoptic data with countries to the east and south of Burma will be satisfactorily solved.

12. Certain recommendations regarding synoptic broadcasts for the benefit of shipping made at the Naval Meteorological Conference in Colombo in March 1930 could not be given effect to at the time on account of financial stringency. During the year under review, however, Government sanctioned a modified scheme for the broadcasting of synoptic data of selected coastal stations from the wireless stations at Bombay, Calcutta and Matara; the Bombay and Calcutta broadcasts commenced from 1st November 1935 and Matara from 1st January 1936.

Training in Meteorology.

13. Two officers of the Siamese Navy were on deputation in this department for training in meteorology. The department also, as in previous years, arranged for the training and examination in meteorology of candidates for Pilots' 'B' license. In all 19 candidates were trained or examined at Poona, Karachi, and Bombay Meteorological offices. Two Aerodrome Officers also received training in Meteorology in the Karachi Meteorological Office. Personal contact between pilots and forecasting officers

was welcomed and encouraged at the forecasting centres. Weather Officers are always glad to show the latest weather charts to pilots and discuss weather situations with them. At places like Jodhpur, Akyab and Rangoon, meteorological assistants frequently meet pilots to elucidate weather reports.

Scientific Investigations and Technical Progress.

14. The Government of India sanctioned the deputation of Dr. Royds, Director of the Kodaikanal Observatory to Japan to enable him to join up with the expedition organised by the Royal Society and the Royal Astronomical Society to observe the total eclipse of the sun on the 19th June 1936. He left Kodaikanal towards the end of March with about a ton of instruments, including what is perhaps the most powerful spectrograph ever used at an eclipse. The discovery of oxygen in the sun's chromosphere, *i.e.*, in the outer atmosphere of the sun, was announced by the Kodaikanal Observatory in a communication to "Nature". Measurements were continued with the spectro-photometer of the intensities of calcium and hydrogen lines in different parts of the sun's disc.

15. At Agra 94 sounding balloons were released and 44 retrieved. A binocular attachment for taking simultaneous readings of horizontal and vertical scales of balloon theodolites was successfully developed. Assistance was continued to Dr. K. C. Mehta of Agra College in connection with his investigations on the transport of the spores for 'cereal rusts'. The study of the seismograms of the North Bihar Earthquake of January 15, 1934 obtained from Indian and a large number of foreign stations was continued at Bombay Observatory, where a preliminary study of the seismograms of Quetta Earthquake of May 31, 1935 was also made. At Peshawar an investigation was made of the relation between night minimum temperature and the humidity on the previous afternoon.

16. In south India, the sounding balloon work was somewhat restricted during the period under review; a number of balloons were, however, released from Madras during the passage of a storm from the Bay. Twelve meteorographs were let off from Poona, 25 from Madras and 17 from Sholapur. Twenty-five out of these have been recovered. A paper in which the upper air conditions in the neighbourhood of tropical storms were discussed and another on the measurement of vertical air currents over Poona were prepared. Considerable progress was made in the study of the detailed distribution of rainfall in south India associated with storms. Special observations of heights of base of low clouds were continued at Poona and Madras. A new forecasting formula for winter rains based on the combined action of the factors previously in use and Agra upper winds was worked out and promised to be a slight improvement on the previous formulæ.

17. Some investigational work was undertaken in the Poona Office with the assistance of voluntary students working under the guidance

and direction of meteorological officers. These included investigations on (*i*) the light from the sky at night, (*ii*) the response of different types of fibres to changes of humidity, (*iii*) the distribution of moisture in the immediate neighbourhood of a water surface, (*iv*) the convection cells set up in a liquid heated uniformly from below, (*v*) development of a spectrograph for studying the distribution of ozone in the atmosphere, atmospheric turbidity and its variations, (*vi*) the dependence of the temperature distribution in the upper atmosphere on pressure at different levels and (*vii*) some problems of solar and atmospheric radiation. A large number of records of earth-air electric current were obtained and analysed. Investigations were also made on the generation of electric charges on liquid drops and solid particles subjected to various mechanical processes.

Agricultural Meteorology.

18. The staff and research students of the Agricultural Meteorology Section were also busy on investigational work, such as, the design and trial of new instruments, comparison of the climates within crops with that of an open space, investigations of the movement of moisture and heat through the air and soil layers near the ground, of the effects of colour and texture of the soil surface on the soil temperatures, of evaporation from free water and soil surfaces, of solar and terrestrial radiation, of "precision" observations on weather and crops. A number of statistical investigations were also in progress, *e.g.*, on the effect of rainfall on the yield of cotton at Akola, the inter-monthly correlations of monthly maximum temperatures in India. Special attention was directed to problems relating to frost and cold wave warnings and a camp observatory was set up at Nasik during the winter months to study the weather conditions affecting the vineyards. The Government of India have agreed to accept the recommendations of the Imperial Council of Agricultural Research for the continuation of the scheme of Agricultural Meteorology for a further period of two years.

Plans and Projects.

19. Perhaps more effort has been expended during the year in planning and discussing possible new lines of advance than in actually putting new projects into being. The discussions of plans to provide meteorological service for the Empire Air Mail Developments have already been mentioned. The R. A. F. Meteorologists at Peshawar and Quetta have hitherto been forecasting from inadequate weather charts, a state which will be remedied from April 1936. There are many other projects which meteorologists would like to see put into force to ensure ordinary normal progress. In particular, an evening weather chart at Poona is wanted, as well as a short-wave wireless station at Poona to ease the distribution of reports for aviation and to enable India better to participate in the international diffusion of weather data, both daily and monthly. Intensive upper air surveys at times of cyclonic storms, and in general an increasing activity in uppper air research, are other desirable items to be undertaken, as soon as money becomes available.

Marine Meteorology—Storm Warnings.

No change was introduced in the system of storm warnings for ports and shipping during the year under report. Storm warnings for the Bay of Bengal and the surrounding areas continued to be issued from the Calcutta Meteorological Office and those for the Arabian Sea area from the Poona Meteorological Office. The number of ports on the warning list was 39 on the west coast of India and 30 round the Bay of Bengal. The latest weather information was supplied as usual to shipping at sea by means of wireless weather bulletins issued twice daily from the coastal radio stations on ordinary undisturbed days and more frequently on days of disturbed weather. The total number of such broadcast messages issued by the Calcutta Office during the year was 1,725 as against 1,776 in the previous year and the number issued by the Poona Meteorological Office was 1,069 against 1,194 during the previous year.

Services to ports around the Bay of Bengal.—Warnings were issued by the Meteorological Office, Calcutta, for 45 periods of disturbed or suspicious weather and probability of thundersqualls. Of these, 12 developed into depressions, of which 4 intensified further into cyclonic storms.

The two storms of October 17th—25th and November 10th—15th were the most important. The first started as a depression in the south-west Bay off the Coromandel Coast on the 17th October; the depression rapidly intensified into a storm and crossed the coast near Madras on the next day. Passing across the Peninsula as a deep depression it moved into the Arabian Sea off Kanara-Konkan and then moved slowly westwards becoming unimportant in the Central Arabian Sea by the 29th. The second storm started as a depression in the south Bay to the east of Ceylon on the 10th November, intensified into a storm and crossed the coast near Negapatam on the 15th. This storm caused heavy rainfall and severe floods in the south of the Peninsula.

The usual circular letters were issued to the 33 port authorities asking for their opinions regarding the warnings issued to them during the year. Twenty-seven of the Port Officers sent replies. Nearly all of them expressed satisfaction with the warnings received by them. Suggestions or criticisms on individual warnings issued and other remarks offered by the Port authorities are always welcomed by the department, as these help to improve the organisation. The total number of warnings issued to ports by the Calcutta Office was 3,658 as against 4,129 in the previous year.

Services to Arabian Sea Ports.—Warnings for disturbed weather were issued by the Meteorological Office, Poona, on 36 occasions. Of these one developed into a storm and two into depressions.

Thirty-four Port Officers sent in their annual returns about the warnings issued to them. Most of them stated that the warnings were timely and satisfactory in every respect and that no change in the present system was necessary. The number of warning messages issued to ports by the Meteorological Office, Poona, was 2,277 during the period under report as against 2,286 in the previous year.

Exchange of information with ships at sea.—The chief sources of marine data are wireless weather messages from ships at sea and extracts from weather logs of ships calling at the principal ports on the Indian seaboard. During the year 9,176 messages were received from ships in the Bay and the Arabian Sea as against 9,745 received during the previous year. The figures indicate satisfactory co-operation between ships' Captains and this department. It is not possible to name here every steamship that sent messages but those that sent 50 messages or more during the year are listed below along with the number of messages received from each :

Name.	Number of messages.	Name.	Number of messages.
1. Alavi	88	29. Jalatarang	177
2. Aungban	177	30. Jalabala	57
3. Badarpur	191	31. Jaladuta	78
4. Barjora	55	32. Jalavijaya	79
5. British Soldier	62	33. Jalamohan	97
6. British Sovereign	97	34. Jalapadma	64
7. British Sailor	120	35. Jalaputra	64
8. Britannia	53	36. Jalaveera	108
9. Carthage	67	37. Jalapalaka	164
10. Chakdina	85	38. Jalajyoti	66
11. Chantala	53	39. Jalavihar	88
12. Chilka	186	40. Khosrou	94
13. Chyebassa	65	41. Karoa	98
14. Corfu	72	42. Khandalla	64
15. City of Evansville	59	43. Karapara	61
16. Cape St. Francis	63	44. Karagola	90
17. Ekma	129	45. Maharaja	131
18. Ethiopia	96	46. Masimpur	200
19. Egra	65	47. Pasha	80
20. Ellenga	84	48. Rohna	102
21. Erinpura	108	49. Rahamani	73
22. Elephanta	57	50. Rizwani	119
23. Garbeta	83	51. Rajula	113
24. Goalpara	56	52. Singu	175
25. Hosang	60	53. Strathaird	98
26. Islami	57	54. Tanfield	58
27. Investigator	87	55. Talamba	113
28. Jaladurga	59		

The second principal source of marine data is the log extracts collected by marine clerks in Calcutta and Bombay and the various steamship agencies. The Port Authorities at Rangoon also continued to render help by allowing the observers of the Time Ball and Tidal Observatory to collect ships' data. Occasionally, in cases of specially important disturbed weather, logs of steamers were collected through the help of the Colombo Port authorities. The British India, the Peninsular and Oriental, the Scindia, the Asiatic, the Bombay and Persia Steam Navigation Companies and the Burma Oil and the Indo-Burma Petroleum Companies have standing arrangements with a number of their ships' Captains to copy and despatch extracts from weather logs on two kinds of forms, which are supplied to them for use during ordinary weather and during disturbed weather respectively. A total of over 3,174 logs was collected during the year.

Aviation Meteorology.

The meteorological offices at Karachi and Calcutta continued to be responsible for the supply of weather reports and forecasts to aviators on the main trans-India route. The Peshawar office and the Quetta office (shifted temporarily to Karachi after the earthquake on the 31st May 1935) continued as usual to supply weather reports and forecasts to the Royal Air Force planes. The Poona office issued forecasts to aircraft in South India, including the Tata Air Mail Service between Ahmedabad and Madras, and between Bombay and Trivandrum. Besides weather reports and forecasts to the regular air mail services, route forecasts and reports were supplied on requisition to various individual fliers, members of the Indian Flying Clubs and Royal Air Force Flying Squadrons.

The system of routine transmission of weather forecasts, pilot balloon data, and current weather reports at fixed times daily along the trans-India air route Karachi-Victoria Point, which was brought into operation from 1st October 1934, worked satisfactorily during the year. The existing meteorological organisation in India for aviation is still far below the standard defined in the International Convention. Nevertheless it was gratifying to receive appreciatory remarks from various aviation interests about the service rendered by the Department.

During the year a few complaints were received from aviators about late receipt of upper wind data or delay in the supply of meteorological reports. Attempts were made to meet complaints as far as the present organisation would allow. Complaints about the late receipt of upper wind data will to a large extent disappear as a result of additional pilot balloon ascents at important stations along the air routes which have recently been sanctioned by Government.

The procedure laid down during the year will lead to an expeditious disposal of all complaints from pilots relating to the service. According to this the aerodrome officers are to pass on complaints which concern this department direct to the nearest representative of this department together with any observations that they may be in a position to make thereon. After the matter is investigated a reply is to be sent direct to the agents of the company. Complaints of a general nature relating to the meteorological organisation are to be addressed direct to the Director General of Observatories. It is hoped that this procedure will eventually lead to an increase in the efficiency of the service.

The total number of aviation forecasts—as distinct from aviation weather reports—issued during the year was 8,624, of which Karachi was responsible for 4,478, Calcutta for 2,967, Poona for 763, Peshawar for 224, and R. A. F. Meteorological Office, Karachi, for 192 including those issued from Quetta before the shift. The number of special current weather reports, and voluntary warnings of adverse weather and

improvement thereof issued by observers along the chain of current weather stations is given in the table below :—

Name of Station.	Number of special current weather reports supplied.	Number of DDMET and MMMET messages issued.
1. Karachi	360	76
2. Jodhpur	388	49
3. Delhi	156	12
4. Allahabad	262	25
5. Calcutta	313	104
6. Chittagong	367	20
7. Akyab	470	64
8. Sandoway	432	32
9. Bassein	627	16
10. Rangoon	740	34
11. Victoria Point	321	2

In addition to the above, 836 current weather reports were supplied by Observatories along the Ahmedabad—Madras route to the Tata Air Mail Service.

For the benefit of airmen, a booklet entitled "Meteorology for Airmen in India" was prepared in two separate parts and sent to press for printing.

Squall Heavy Rainfall and Frost Warnings.

Inland Weather Warnings and Forecasts.—The majority of officers to whom warnings of heavy rain and strong winds on land are issued from Poona and Calcutta meteorological offices were district officers and officers of the Irrigation, Railway, Police, Telegraph and other departments. The number of officers on the Poona Warning list was 160; the number on the Calcutta Warning list was 149, including 12 officers of the Telegraph Department, 8 river ports, 13 river stations and 58 police stations. In addition to these, the number of officers in Bengal who receive only "Great Danger Warnings" was 415. Apart from these specific warnings to individual officers, the Daily Weather Telegraphic Summary contains heavy rainfall forecasts, and all its subscribers and others to whom the information becomes accessible thus receive these warnings. During the year under review the Meteorological Office, Calcutta, issued 2,944 inland warning messages including special weather bulletins for river-craft and warnings of the probability of thundersqualls in Bengal, while the Meteorological Office, Poona, issued 1,412 inland warnings including warnings for low temperature and occasional special messages. The number of heavy rainfall telegrams sent direct to various officers by local meteorological observers was 252. Reports on the working of the inland warning system were received from 39 officers on the warning list of Poona and 40 officers on the warning list of Calcutta and almost all of them expressed general satisfaction with the warnings issued.

A few officers had minor criticisms to offer about individual forecasts of heavy rain not being received in time, or not proving correct. These received special examination to see how far the lessons to be learned from them could be of use in future work.

OFFICES AND OBSERVATORIES.

In regard to the "Functions and Organisation of the India Meteorological Department" a reference is invited to the 1935 edition of the pamphlet on the subject, issued by the Government of India, Department of Industries and Labour.

Headquarters Office, Poona.—Dr. S. K. Banerji officiated as Director General of Observatories from 20th July to 8th October 1935, while Dr. C. W. B. Normand was on deputation to Europe to attend the Empire and International Meteorological Conferences.

The scientific work done in this Office has been briefly mentioned under the Chief Features. Twenty-one meetings of the colloquium were held during the year under report. As in previous years the discussion at each meeting was opened by a member of the staff or one of the research students, or some outside scientific worker who took as his subject either his own original work or a recent important paper published in an extra-departmental scientific journal. As in past years, co-operation was extended to the International Meteorological Commission in the matter of compilation and tabulation of all observations made in India for the International Polar Year Commission. The work is nearing completion.

The 23rd Session of the Indian Science Congress was held at Indore in January 1936 and 5 officers were deputed to attend its meetings. The Director-General of Observatories was re-nominated by the Government of India to be a member of the court of the Indian Institute of Science, Bangalore, for the period 1936-40.

A piece of land measuring 9,721 sq. ft. with a small building on it, adjoining the compound of Poona office, was acquired for the Department.

The activities of different sections of the Headquarters Office are briefly described below :—

(*a*) *General Section.*—This section deals with matters relating to the administration of the Headquarters and Sub-offices including such items as budget, accounts, establishment, general registry, and technical questions relating to aviation and matters involving fresh expenditure as well as arrangements for the co-ordination of technical work in the department.

The development questions relating to the air routes received considerable attention during the year. Under the Capital Expenditure scheme for the development of air routes in India, which was approved by Government during the previous year, offices and residential quarters for the staff of this department are to be constructed at aerodromes. The progress made during the period under report in

this connection, involved the settlement of many details of siting and layout in co-ordination with the department of civil aviation, and the examination of plans and estimates of most of the buildings prepared by the Central Public Works Department.

The scheme for the Development of Empire Air Mail Services across India was under consideration and gave rise to a considerable amount of correspondence and additional work in the section. This scheme is expected to come into operation during the next two years. The problem of providing the essential meteorological reports cheaply under changed conditions received the most careful consideration. Estimates for meteorological requirements in connection with the expected developments in air services involving day and night flying by land and seaplanes were prepared and submitted to Government with full justification of the different proposals and details of the expenditure involved. The development will involve sending up illuminated balloons for measurement of upper winds at night, installation of searchlights for determination of cloud heights, special arrangements for measurements of visibility at night, and provision of extra staff for night attendance, at important stations along the routes over which night flying will be resorted to.

The departmental pamphlet "Meteorological Organisation for Airmen in India" was revised, and a fresh edition was published.

(*b*) *Weather Section.*—This section is responsible for the issue of warnings to shipping and ports in the Arabian Sea, of weather reports to aircraft in the Peninsula, of daily weather telegrams which appear regularly in newspapers, the Daily, Weekly, and Monthly Weather Reports and for the preparation of portions of the Annual Summary of the India Weather Review. It also issues warnings in respect of heavy rainfall and frosts.

During the year, the Bombay-Trivandrum weekly air service operated by Tata Sons, Ltd. began to function and the supply of weather reports for this service was commenced as a regular measure.

Arrangements were made for the issue from the W/T stations at Bombay and Matara of broadcasts of synoptic data of selected Indian stations, for the benefit of shipping in the Arabian Sea.

The daily data of upper winds from the pilot balloon stations and of temperature and humidities obtained from aeroplane ascents at Peshawar and Karachi and wireless reports from ships began to be published in the Indian Daily Weather Report with effect from 1st January 1936.

A note on the snowstorms and blizzards over Nanga Parbat during the second week of July 1934 was prepared for Dr. Karl Wien of Hanover, Germany. A brief climatological note on the weather conditions for the route Calcutta-Batavia during the months July and August was supplied for the use of Lady Chetwode. Climatological notes for the air route Karachi-Calcutta-Victoria Point were supplied to the Secretary, the Federacion Aeronautica Espanola, Madrid. Wind

frequency tables for the month of February for the air route Madras-Hyderabad-Bombay were prepared for the Deputy Director of Civil Aviation, New Delhi.

Five candidates were given training in Meteorology for the Pilots' 'B' license examination and one was examined.

It was decided to include all the Collectors in the Bombay Presidency in the warning list for heavy and untimely rain and excessively low temperatures. In conformity with the change in the second form of the International Code for land stations, arrangements were made for the reporting of height of base of low cloud above ground in the weather messages.

In connection with the Viceroy's Trophy Air Race, weather reports and forecasts for Madras-Hakimpet-Bombay and Bombay-Ahmedabad routes were supplied for the use of competitors in the Air Race at Madras and Bombay respectively, and the latest upper air data of Hyderabad, Poona and Bombay were made available at the Hakimpet aerodrome.

(*c*) *Observatories Section.*—This section continued to administer and arrange for the inspection of departmental observatories in Central and South India. Inspection of 54 observatories under the Headquarters office was undertaken during the year under review. One third class non-departmental non-reporting observatory was started at Ootacamund. Consequent upon the closure of the Quetta meteorological office after the disastrous earthquake on the 31st May 1935, a temporary second class observatory was started some months later at the Agricultural Farm, Quetta. In connection with the Hardwar-Gauchar air-service, steps were taken to start a non-instrumental observatory at Gauchar which is to record 3 observations per day and telegraph one observation a day to Hardwar.

The observatory at Nasik was instructed to telegraph temperature observations to Poona daily for 3 months from 1st December 1935 to 29th February 1936.

The compilation and printing of a revised and enlarged edition of the departmental Cloud Atlas was in progress.

(*d*) *Instruments Section.*—The section continued to be responsible for the purchase, test, standardisation and repairs of meteorological instruments and the issue of these instruments as well as supply of forms and stationery to departmental surface observatories.

During the period under report, 815 new instruments were purchased and 680 instruments were recalled from observatories; 1,139 instruments were issued to departmental observatories and 1,963 items of stores and instruments were issued to officers, sections and research students at Headquarters; 73 instruments were loaned; 1,086 instruments were tested, and 285 were repaired. An electrical anemometer of robust type was specially manufactured for and loaned to H. M. I. S. "Investigator". Some special stands for Marine Clerks' standard

barometers were made to departmental design and supplied to the sub-offices concerned.

A tour was arranged for the direct comparison of the departmental standard barometers and the existing corrections were modified wherever necessary. New barometers of improved pattern were supplied to Karachi and Calcutta meteorological offices for use as sub-standards. Specifications for 7 instruments were drawn up. Copies of departmental specifications for thermometers and wind-vanes were supplied to a few local firms to enable them if required to keep stock of these instruments for intending purchasers.

Work on atmospheric electricity at Poona was continued. The departmental workshop at Poona was equipped with "Engraving" and "Polishing" machines and an additional lathe.

Thirty-four enquiries from outside parties regarding specifications, etc., of meteorological instruments were replied to. About 1,702 visitors were shown round the office and the observatory on 163 occasions, and small exhibitions were arranged on 23 occasions, in this connection. The collection of instruments and photographic exhibits was continued and further progress was made for an early setting up of the proposed museum at the Poona office.

A suitable aerial was installed at the Poona Observatory to obtain signals from radio-meteorograph as well as time-signals from Rugby, England.

(*e*) *Marine Section.*—The usual duties of the section, namely the co-ordination of the work of collection, examination and study of ships' weather logs were carried on satisfactorily. The scrutiny, computation and tabulation of all observations in Region D made for the International Polar Year Commission were completed.

The present scheme for wireless reports from ships was, at the request of the International Commission of Maritime Meteorology, examined and reported on. The report pointed out that the present international hours, as also some of the hours at present prescribed for observations according to the Indian Ships' Weather Code were unsuitable, the latter chiefly with regard to the W/T. watch-keeping periods of single operator ships, and that both forms of the International Ships' Code were unsuitable for this department's needs and resources. It was, therefore, proposed that another form of the International Ships' Code which would provide for reports of state of sea and would exclude elements like ship's course and speed, high and medium clouds, characteristic and amount of barometric tendency not useful in Indian waters, and the midway hours (03, 09, and 21 GMT) between the present international hours be recognized internationally. The two proposals have since been accepted.

Data of the marine observations at the 3 daily periods were regularly received from the H. M. I. S. "Investigator" and scrutinised. As in previous years, essays in Meteorology by cadets of I. M. M. T. S.

"Dufferin" were judged and the usual prize of an aneroid was presented to the cadet who stood first in Meteorology.

A draft new edition of the Code of Storm Warning Signals was under preparation. The question of making 0300 hrs. G. M. T. the hour of routine morning observations at sea was under consideration both for (i) Indian and (ii) Foreign ships.

During the period under report, Government sanctioned a modified scheme for the broadcasting of synoptic data of some selected Indian stations from Calcutta, Bombay, and Matara, for the benefit of shipping in Indian waters. The synoptic broadcasts from Bombay and Calcutta W/T commenced from the 1st November 1935 and Matara W/T from 1st January 1936. A foolscap size chart entitled the "Indian Seas Weather Chart" was published for the use of ships which desire to plot the data of the synoptic broadcasts.

(*f*) *Upper Air Section.*—Sounding balloon work was continued but ascents were mostly made with a view to elucidate particular problems. A large number of ascents was made from Madras when a storm in the Bay was affecting the Madras coast. During the year under report 12 meteorographs were let off from Poona, 25 from Madras and 17 from Sholapur. Twenty-five out of the above total of 54 have been recovered.

Observations of upper air temperatures and humidities continued to be made from aeroplanes by the Royal Air Force at Peshawar and Karachi and the data were worked out at Poona in a form suitable for publication. From January 1936, these data are being received by telegram, and are being published as a supplement to the Indian Daily Weather Report instead of in the publication 'Upper Air Data'.

Pilot Balloon and other data of Region D (according to the classification of the International Aerological Commission) for the period January to July 1932 were sent to the President of the Commission.

Special observations of the heights of base of low clouds were again made at Poona and Madras during the southwest and northeast monsoons respectively. At Poona observations were also taken on several nights using a searchlight. Observations from 28 pilot balloon ascents made from H. M. Ships in Indian waters were received by post and the results worked out in a form suitable for comparison with the departmental data. The tables of wind frequencies up to 3 kms. published as Scientific Note No. 17 were revised using all upper air data up to the end of 1934. From the monthly normal change of wind with height obtained from pilot balloon observations, normal horizontal temperature gradients in the atmosphere in different parts of India were calculated and maps were prepared showing the normal distribution of temperature at different levels in the atmosphere in each month.

(*g*) *Statistical Section and Library.*—The duties of this section include statistical work connected with the issue of the seasonal forecasts and with climatology; the care of the library, the editing and

distribution of departmental publications and the supply of general meteorological information in reply to enquiries are also included in the work of this section.

Statistical work to improve the reliability of the existing forecasting formulæ was continued as in previous years. Some fresh forecasting formulæ were worked out, after leaving out those factors which had been shown to have but little significance by the performance test. A new formula for winter precipitation taking the present factors and including one more factor, viz., upper winds at Agra, was calculated and brought into use; the resulting joint correlation co-efficient is ·72 as compared with ·58 of the previous formulæ. Five long-range forecasts were issued during the year, all of them being successful. Since 1931, when the performance test began to be applied, 25 out of the 27 forecasts issued have been successful.

The number of books, pamphlets and periodicals either purchased or received in exchange for the publications of the department or as complimentary copies was 714. A catalogue of periodicals in the library of the Headquarters Office, Poona, and in the libraries of the other offices of the department was compiled and sent to press. Six papers were received for publication during the year; four were published, or sent to press, as Scientific Notes and two as Memoirs. Appendix B (page 35) gives a list of the publications issued by the department, as well as of papers and notes contributed by members of the staff to non-departmental journals. The number of addresses on the free distribution list of the departmental publications was 378. About 358 enquiries for climatological, meteorological and occasionally astronomical information were received and answered.

The routine activities of the Climatological Branch consisting mainly of scrutiny of the accuracy of records of surface observatories, preparation of meteorological tables for the routine publications of the department and supply of periodical meteorological reports and data to various Government and Public Officers, were carried on satisfactorily.

The usual advisory functions of the Director General of Observatories with regard to the registration of rainfall, inspection of rain-gauges and the publication of the provincial tables were also carried out.

(h) Agricultural Meteorology Section.—This section devoted most of its time to work on the "experimental or biological" aspects of Agricultural Meteorology and maintained intimate contact with agricultural institutions and workers in India and with the many meteorological problems, which their work gives rise to. A number of agricultural workers were advised about standard meteorological equipment and its installation in farm observatories on selected sites, their assistants were trained in observational work and instruments were repaired or standardised, when sent to Poona.

Workers at some of the representative agricultural centres in India have begun to co-operate with the section in conducting fundamental work on the climates of crops and precision measurements of their

growth and yield. Enquiries relating to the meteorological aspects of their investigations were also received from officers in charge of research work on dry farming, sugar cane, locusts and cereal rust.

At the instance of the Imperial Council of Agricultural Research arrangements were made as an experimental measure to issue cold wave warnings to those provinces and Indian States which are liable to the incidence of frost in winter. Various methods of frost prevention were discussed with the Department of Agriculture, Bombay Presidency and experiments to test the efficacy of different types of fires, wind screens and irrigation were conducted in January and February 1936 in collaboration with the Deputy Director of Agriculture at Nasik. A camp observatory was installed at Nasik to help in the above experiments. These experiments will form the basis for advice to grape growers regarding remedial measures against frost-damage.

At the request of the Government of Bombay a provisional scheme for issuing heavy and untimely rainfall as well as cold wave warnings, to the various districts of the Bombay Presidency was drawn up in consultation with the Weather Section at Poona and collectors of districts. This scheme is to be tried as an experimental measure for two years with effect from June 1936.

The Central Agricultural Meteorological Observatory at Poona continued to be the main centre for experimental investigations. Investigations were carried out on the climates of different crops as compared with those of neighbouring open spaces, and on precision observations on the growth and yield of crops, and a number of new instruments of local construction were tested. Arrangements were also made during the year to complete the equipment to investigate the "thermal balance" as well as the "moisture or water balance" at the earth's surface. An instrument devised for the measurement of heat loss by convection near the ground and another for the direct measurement of soil moisture by using a porous candle manometer may be mentioned in this connection. Besides regular observations of evaporation from soil and water surfaces, of radiation from the sun and sky, etc., the experiments on control of soil temperatures by using thin soil covers and the variation of soil temperatures in blocks of different soil types were also continued. Investigations on the exchange of moisture between the soil and the air layers near the ground during the clear season were in progress. These investigations show that this phenomenon sets a limit to the loss of moisture from the soil, once a dry surface mulch is formed. The effect is most pronounced with the black cotton group of soils and least so with the alluvial group.

A number of statistical investigations were also in progress during the year. The study of weather in relation to the cotton crop in the Bombay Presidency and a statistical analysis of rainfall in the Mysore State were completed. A study of the correlation coefficients of

monthly maximum temperatures between successive months at representative stations in India showed that the centre of high correlation moves down to South India during winter and returns to N. W. India with the onset of the southwest monsoon. These movements are associated with the movement of the sub-tropical belt of high pressure in India. An investigation on the effect of rainfall on the cotton yield at Akola was also completed.

The list of papers discussing the results of investigations made by the staff and research students of the section is given in Appendix B (page 35).

Upper Air Observatory, Agra.—This observatory administers all the pilot balloon stations of the department except those at other departmental centres such as Poona, Karachi, Calcutta or Bombay. The diversion of the Karachi-Lahore Air Service route led to the pilot balloon station at Sukkur being shifted to Jacobabad. As a result of the earthquake disaster at Quetta on 31st May 1935 the Upper Air work at Quetta was stopped, and later a new pilot balloon station was opened at Dera Ismail Khan in place of Quetta. The pilot balloon observatory at Muscat was shifted to Sharjah and that at Silchar to Tavoy, both Sharjah and Tavoy being stations on the main air-route and are provided with wireless communication. The total number of pilot balloon stations was 36, as in the previous year. The quantity of hydrogen manufactured for balloons during the year was 243,399 c.ft. as against 209,418 c.ft. during the previous year.

The sounding balloon work was carried on a restricted scale owing to financial limitation. Ninety-four sounding balloons were sent up from Agra and 12 from Jodhpur. Forty-four instruments were retrieved out of the lot sent up from Agra and one from Jodhpur. Experiments were undertaken with the modified Dines Meteorographs with a view to eliminate the zero shift of pressure and temperature. Dies for an improved type of meteorograph aneroid were made. Experiments were also carried on with the following new instruments :—

(1) Purity indicator for hydrogen and (2) electrical gasometer recorder.

As a time saving device for current weather work a simple electrical attachment to the I. M. D. anemometer was made to determine wind velocity from the observers' office. Some further improvements and additions were made in theodolites for night work.

Tests were in progress for using "Cellophane" for making balloons. Some improved methods of testing rubber tissues as regards their suitability for sounding balloons were introduced. As in previous years assistance was given to Dr. K. C. Mehta of the Agra College in his investigations on the transport of the spores for "cereal rusts".

The duties of a first class observatory and seismological station were carried on as usual. The number of upper air observatories inspected by gazetted officers during the year was 4. The observatory, as usual,

prepared the manuscripts of monthly means of upper winds, frequency tables for directions of movements of cloud and ground wind, seismic data, sounding balloon data, and daily pilot balloon data for routine publications of the department.

Training was given in elementary meteorology to 4 candidates for pilots' 'B' license.

Arrangement was made for a meteorological exhibition during the opening ceremony of the Willingdon Air Station at Delhi.

Colaba and Alibag Observatories.—These observatories which form the departmental centre for geophysical studies, carried on as usual, the routine meteorological, seismological, magnetic and atmospheric electricity work. The Colaba Observatory also maintained a time service for the Port of Bombay and continued to stock the Royal Indian Navy chronometers and watches for maintenance and rating, the average number of instruments for daily rating was 75.

Copies of the observatory volume for 1933 were distributed and the volume for 1934 sent to the press. A number of photostat copies of Colaba seismograms, particularly of the Baluchistan Earthquake of 31st May 1935 and its aftershocks were sent on request to several seismological and geophysical institutes. Eight seismic radiograms relating to earthquake shocks of moderate or great intensity were sent to the Kew Observatory, London. A study of the seismograms of the North Bihar Earthquake of January 1934, obtained from the Indian and the neighbouring extra-Indian stations was continued. It was decided to continue at Colaba the work of scrutinising and collating seismological observations made at the departmental seismic stations.

At the Alibag magnetic observatory continuous records of the various magnetic elements were taken and the observations of the absolute values of these elements were made as usual. Data regarding the magnetic character of days and the daily range of variations of magnetic elements were supplied regularly to the Royal Meteorological Institute, De Bilt, and the Solar Physics Observatory, Kodaikanal. Two sets of ferro-prints of the Alibag magnetograms for the Polar Year, were forwarded to the International Commission at Copenhagen and to the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. A suitable note on these magnetograms and the hourly values of magnetic elements during the Polar Year were compiled for incorporation in the Polar Year Volume.

Measurements of the atmospheric potential gradient were continued. As an experimental measure observations of atmospheric conductivity with a Gerdien apparatus were commenced from July 1935.

Both at Colaba and Alibag, observations of meteorological elements by self-recording and eye-reading instruments were carried on as usual. As in previous years, the Gestetnered Daily Weather Report giving a summary of principal features of weather over western India based on material telephoned from Poona was issued regularly during the period

1st May to 30th November. The pilot balloon station sanctioned for Juhu in connection with Karachi-Madras Air Service was transferred to the administrative control of Meteorologist, Bombay with retrospective effect from 28th June 1934. It remained located at Colaba, and regular upper air observations were made throughout the period under report.

The collection of weather logs from ships calling at Bombay Port and the determination of the correction of the barometers were carried on as usual. A few candidates were trained in elementary meteorology during April to June 1935, and one of them was examined for Pilots' 'B' license.

An accidental fire in the western wing of the observatory building in the early morning of 7th March 1936 completely demolished the photographic room.

Alipore Observatory and Meteorological Office, Calcutta.—The principal functions of this office, namely, storm warning for the Bay of Bengal, heavy rainfall warnings for northeast India and the surrounding areas, squall warnings for Bengal, the issuing of weather reports and forecasts for aviators including the regular airmail sevices on the air route between Allahabad and Victoria Point were carried on satisfactorily.

The Calcutta Office continued to publish the Calcutta Daily Weather Report as usual throughout the year. A Daily Weather Report for Burma was also issued for a few months of the year and delivered to the Associated Press of India for transmission to Rangoon. For the benefit of shipping, the issue of the Calcutta synoptic broadcasts through the Calcutta W/T station, commenced from 1st November 1935, and through the Matara Radio Station from 1st January 1936.

This office was also responsible for the administration of 101 surface observatories, besides the Alipore surface observatory and the upper air observatory for Dum Dum. Sites for 8 second class observatories in Burma, 2 in Bengal and 1 in Assam were selected. During the period under review 42 departmental and two non-departmental observatories were inspected and one second class observatory was started.

The meteorological and seismological observations as well as time-determination, and time signalling work of the Alipore Observatory were carried on as in previous years. The work of testing the meteorological instrument of the Mathematical Instrument Office, Calcutta, of the Chemical Examiner to the Government of Bengal, Calcutta, and of ships' captains was carried on as usual. At the request of Commander Norcock of the Port Commissioners, Calcutta, arrangements were made to give the senior men of the Port Commissioners' light vessels some training in meteorology at the Alipore Observatory.

This office continued to collect and examine logs from ships in respect of the Bay of Bengal. There was a greater demand from the public for meteorological and other information and this was attended to.

In connection with the Calcutta Aerodrome Project, comparative visibility observations were recorded at Gorgacha, Dum Dum and the Ochterlony Monument, at the instance of the Civil Aviation Directorate.

Meteorological Office, Karachi.—This office continued to furnish aviation weather reports and forecasts for the main air route from Bahrein on the west to Allahabad on the east, and also for the air routes between Karachi and Ahmedabad and Karachi and Lahore. A new air service between Hardwar and Gauchar worked for some time during the year. The aviation forecasting work during the period under report increased by almost 100 per cent. over that of the previous year. Forecasts for the route Karachi-Jodhpur-Delhi and other routes were also supplied to the Royal Air Force whenever required.

After the earthquake at Quetta, the R. A. F. Meteorological office was transferred to Karachi. It was accommodated in the premises of the Karachi Office. Observational data were supplied as in previous years to the Meteorological officers at Peshawar and Baghdad. Special arrangements were made for the supply of weather reports and forecasts to R. A. F. flying boats over the Indian area on several occasions in August and September 1935. The total number of aviation forecasts and reports issued to the R. A. F. during the period was 185. The total number of surface and upper air reports supplied through the Royal Air Force Wireless Station for Royal Air Force forecasting centres was 3,878, and the number of surface and upper air reports received through the same Wireless Station was 2,052. The R. A. F., Drigh Road made 41 aeroplane temperature flights during the period under review as compared with 17 flights during the previous year. Information about wind direction and velocity at different heights over Drigh Road was supplied to R. A. F. whenever required.

The Karachi Daily Weather Report continued to be published on an experimental basis. Warnings for adverse weather and anticipated rainfall or frost were issued on 395 occasions, the number of officers on the warning list being 11. Sixty-two requests for meteorological data from Government and private bodies were complied with. Besides these, 194 routine items of information were supplied. This office continued to co-operate with the Locust Research Entomologist by supplying the meteorological data required and by arranging frequent discussions regarding weather conditions.

Pilots of the Imperial Airways, the I. T. C. A. and the Tata Air Service frequently visited Karachi Office to see the weather charts and to discuss weather situations for their impending flights.

Training in elementary meteorology was given to two Aerodrome Officers of the Karachi Aerodrome, and 9 candidates for the Pilots' 'B' license. The number of candidates examined in elementary meteorology for Pilots' 'B' license was 7.

The total number of observatories administered by the Karachi Office was 81; of these 32 were inspected during the year. The observatory at Henjam was closed down. After the shift of the pilot balloon station from Muscat to Sharjah, a 2nd class surface observatory was started at the former place.

The observatory at Drigh Road continued to function as a first class surface and upper air observatory as well as an auxiliary centre. It also served as an agency for the distribution of weather reports and forecasts to pilots and for the receipt of their requisitions.

Kodaikanal Observatory.—The solar and astronomical researches carried on during the calendar year, 1935, have been summarised in the Annual Report of the Kodaikanal Observatory. The routine work of the observatory was carried on as in previous years.

Co-operation was extended to other observatories under the auspices of the International Astronomical Union in respect of prominence statistics. Daily character figures of solar activity as regards $H\alpha$ bright flocculi and $H\alpha$ dark markings for the year 1935 were communicated to the Observatoire. Federal, Zurich, for publication. Daily character figures for calcium flocculi from Kodaikanal photographs were furnished to the Solar Physics Observatory, Cambridge. Sixty-four calcium disc spectro-heliograms for the last quarter of 1935 were sent to Solar Physics Observatory, Cambridge, and 15 photo-heliograms were sent to the Astronomer Royal, Greenwich Observatory.

Regular observations of the sun were made with the Hale spectro-helioscope on all days except Sundays and holidays, whenever the weather permitted. Photometric studies of the calcium and hydrogen lines in different parts of the sun's disc were continued. Evidence was obtained of the presence of oxygen in great abundance in the sun's chromosphere up to considerable heights.

The Government of India sanctioned the deputation of Dr. T. Royds, Director of the Kodaikanal Observatory, to Japan to observe the total eclipse of the sun on the 19th June 1936. Dr. Royds left India for Japan on the 24th March 1936.

Meteorological Office, Quetta (temporarily shifted to Karachi).—This office continued under the charge of an officer deputed from the Indian Meteorological Service but paid by the Royal Air Force. The earthquake of 31st May 1935 demolished the meteorological office at Quetta and the staff had to shift temporarily to Karachi where they arrived on 5th June 1935. The upper air observers were later transferred to Dera Ismail Khan.

A general inference and forecast of weather over Sind, Baluchistan, and the Punjab was telephoned every night (except on Saturdays) to

SEISMOGRAMS OF
BALUCHISTAN EARTHQUAKE, FRIDAY MAY 31st, 1935.
(COLABA OBSERVATORY)

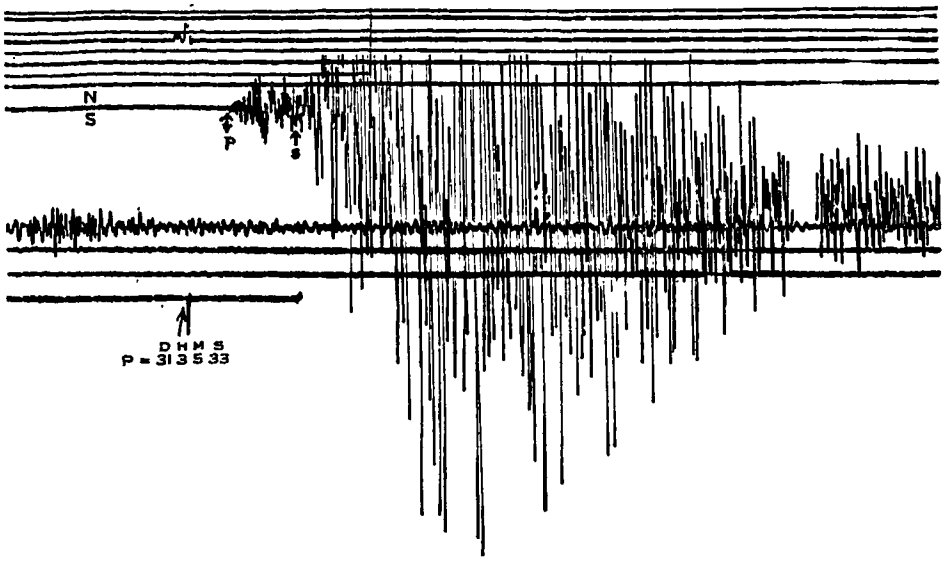


Fig. 1.—Milne-Shaw; North-South Component.

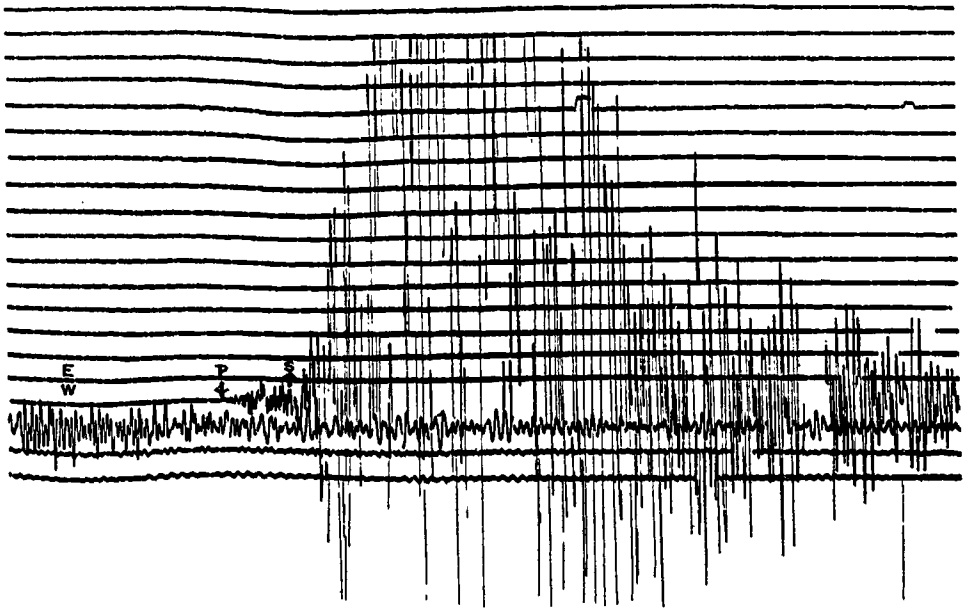


Fig. 2.—Milne-Shaw; East-West Component.

Figures 1 and 2 are the record of one of the most disastrous earthquakes which occurred in Indian area during the last 100 years. Calculations based on the times of arrival of preliminary and secondary waves show that the time of beginning of the earthquake at its origin was 3 hrs. 3 mins. (Indian Standard Time) on May 31, 1935 Although felt over a comparatively small area, probably not more than 100,000 square miles, it caused great damage both to life and property. The epicentre where the greatest damage was sustained, extended from the northwest of Quetta to half-way between Mastung and Kalat. At Quetta, the shock lasted for nearly half a minute; during this time the whole of the Quetta city, part of Civil Lines, the Railway Quarters, the Police Lines, and the R.A.F. Lines were laid in ruins. The Meteorological Office at Quetta, which was located in the R.A.F. Lines, was also completely demolished.

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the Aircraft Depôt, R. A. F., Drigh Road. A copy of the general and local forecast was also supplied to the Officer Commanding No. 31, A. C. Squadron, R. A. F. (formerly at Quetta) and the G. O. C. Western Command, Karachi. Morning surface and upper air observations were also telephoned to Aircraft Depôt and No. 31 A. C. Squadron and arrangements were made to exhibit the routine forecasts and the data on a notice board. Apart from the routine forecasts there were also route forecasts and special weather reports to be supplied whenever requisitioned. During the period under review the route forecasts issued numbered 192 and the special weather reports about 35. Special warnings of thunderstorms, duststorms, squalls, etc., were also supplied on a few occasions. A number of requests from the R. A. F., and other civil and military authorities for meteorological data by letter were complied with.

Observations of upper air temperature and pressure by R. A. F. planes were obtained at Quetta on about 40 occasions, and at Karachi on 27 occasions. Arrangements were made to obtain about 3 sets of upper air observations per week by planes of No. 31 A. C. Squadron. A few trial records were obtained with a Bosch thermograph on aeroplanes.

An officer of No. 31 A. C. Squadron R. A. F. was trained and examined in Elementary Meteorology. Instruction in meteorology was also given to two airmen of the Aircraft Depôt and to some officers of the Indian Air Force.

Meteorological Office, Peshawar.—This office which also functions as a first-class observatory and an upper air station, continued under the charge of a R. A. F. Meteorological Officer, who is under the technical control of the Director General of Observatories. A weather report and forecast for the area North-West Frontier Province, Sind, North Baluchistan, Punjab, was issued at about 08 hrs. daily by this office (except on Sundays and holidays) through R. A. F. W/T to all R. A. F. stations in the Punjab and the North-West Frontier Province. A more detailed weather report and forecast for the Peshawar district was issued daily at about 08 hrs. to the local Group and Squadron H. Q. of the R. A. F. as well as to Peshawar District and Brigade Headquarters and Government House. Heavy rainfall warnings were issued periodically to the local canal office of the P. W. D. and special warnings of storms, squalls, poor visibility, etc., were issued when necessary to R. A. F., military and civil authorities.

Arrangements were made to supply the Government Publicity Officer, North-West Frontier Province, with a local weather report and forecast for inclusion in the daily programme of the Peshawar broadcasting station. Special forecasts were issued daily to military units engaged in operations on the frontier and in the Mohmand area. Two hundred and twenty-four route forecasts were issued to R. A. F. units, and 19 'meteor' telegrams were supplied to artillery units. Observations of upper air temperatures were made by the R. A. F. units at Peshawar, Kohat, and Risalpur on 294 days. Miscellaneous data,

reports, and forecasts were supplied to several officers and institutions such as Anti-Malaria Office, Canal Office, Chemical Defence Research Establishment, Agricultural Officer, Deputy Commissioner, Peshawar Vale Hunt, etc.

A conference of R. A. F. Meteorologists met at Peshawar in November 1935 to formulate proposals regarding improvement in the meteorological organisation for the R. A. F.

Other Observatories.—The numbers of observatories of various classes are shown in the table below, with the corresponding figures at the end of the previous year.

	On 31st March 1936.	On 31st March 1935.
I Class	14	15
II Class	169	168
III Class	87	85
IV Class	23	23
V Class	24	24
Non-Instrumental	15	15
* Total	332	330
Non-departmental	62	60

* This total includes the non-departmental observatories whose number is shown separately in the next row.

The records of the non-departmental observatories were scrutinised by this department and in most cases utilised in the daily weather reports and other departmental publications. The importance of these observatories need hardly be emphasised and the co-operation of the Indian States and other public bodies, who maintained them for the furtherance of the study of Indian meteorology, is much appreciated. Among these may be mentioned the Kingdom of Nepal and the States of Hyderabad, Kashmir, Mysore, Baroda, Bhopal, Travancore, Bahawalpur, Bikaner, Jaipur, Cooch Behar, Jhalawar, Nawanagar, Ichalkaranji and Miraj, the municipalities of Ahmedabad, Coonoor, Murree and Mussooree and the Agricultural Departments of Bombay and the Punjab.

Rainfall Registration.

The rainfall data collected by the provincial rainfall organizations for which the Director General of Observatories is the consulting authority, are published in the provincial rainfall tables, which are collected and issued in a single volume for the whole of India by this department. The number of stations included in the organisation in the different provinces and the number inspected during the year, together with corresponding figures for the previous year, are given in the following table. On the whole the work of rainfall registration was carried out satisfactorily throughout India.

Rainfall Registration during 1935-36.

No.	Province.	Number of raingauges at the end of			Number of raingauges inspected.		
		1935-36.	1934-35.	Change.	1935-36.	1934-35.	Change.
1	Burma	215	214	+1	209	210 (a)	—1
2	Assam	128	128	0	115	96	+19
3	Bengal	236	236	0	206	204	+2
4	Bihar and Orissa	282	276	+6	257	261	—4
5	United Provinces	273	269	+4	246	264	—18
6	Punjab	195	195	0	172	176	—4
7	Jammu and Kashmir	30	30	0	7	7	0
8	N. W. F. Province	30	30	0	28	26	+2
9	Baluchistan	78	78	0	67	74	—7
10	Sind	61	61	0	51	50	+1
11	Rajputana	188	187 (a)	+1	172	169 (a)	+3
12	Bombay	200	200	0	176	168	+8
13	States in Bombay Presidency.	79	80	—1	48	46	+2
14	Central India	121	121 (a)	0	106	105 (a)	+1
15	Central Provinces	166	167	—1	159	163	—4
16	Berar	42	42	0	41	40	+1
17	Eastern States	46	46	0	45	45 (a)	0
18	Hyderabad	58	55	+3	0	0	0
19	Mysore	75	75	0	75	75	0
20	Coorg	20	20	0	19	18	+1
21	Madras	513	514	—1	484	493	—9

(a) Revised figures based on information received subsequently.

Heavy Rainfall Reports.—Heavy rainfall is sometimes so very local that small unrepresented areas can have as much as 10 inches without the present net-work of daily reporting stations conveying the least suggestion of the local deluge. To obtain reports of such local heavy rain promptly for the daily weather report, it was arranged 15 years ago that observers at all raingauge stations at district headquarters in British India as well as in Indian States should telegraph to forecasting centres falls of 5 inches or more. The number of such telegrams received during 1935-36 was 171.

Snowfall Registration.—Information about the distribution and the time of occurrence of snowfall in the Himalayas and the Afghan mountain areas was on the whole tolerably complete and the thanks of the department are due to the various officers who collected and forwarded the reports.

International Meteorology.

During the last decade international meteorology has made very rapid strides; progress which has been marked both in theoretical meteorology and in practical application to human activities particularly

in respect of marine and aerial navigation, agriculture, engineering, and hydrology, has been mainly due to the standardisation of methods of international exchange of continental and marine reports, the development of improved technique for upper air exploration and the application of well-established physical laws to forecasting. India has maintained as close touch with the international developments as possible.

The Director General of Observatories attended on deputation the meeting of the Empire Meteorological Conference held in London from August 12 to 21, 1935. The Empire Meteorological Conference was the third of the series and as many as 25 different parts of the Empire were represented at the meeting. Every dominion and colony, which possesses an organised meteorological service, was represented by the Director of the service. The conference offered an invaluable opportunity for personal contacts between Directors from practically every quarter of the empire, giving them an opportunity to exchange their experience and pool their information. The Empire Conference was partly a dress-rehearsal for the later International Conference at Warsaw, in that it gave an opportunity of learning about and discussing some of the resolutions that were to be put forward by the expert International Commissions for acceptance at the International Conference at Warsaw. Of more importance than the dress-rehearsal, however, was the inclusion on the agenda of a series of items of general interest, and the exchange of views and experience of different countries regarding them. At this conference discussions were mainly directed to the application of meteorology, to commercial aviation, agriculture, defence services, and navigation at sea.

The proposed development of Empire Air Routes gave the application of meteorology to commercial aviation a prominent place in the agenda of the meeting. The meteorological services will play a very important role in maintaining the regularity of the Air Mails and therefore in the ultimate success of the scheme. The proposed development will require the provision of more adequate meteorological facilities along all sections of the route.

The Director General of Observatories also attended the International Meteorological Conference at Warsaw from 6th-13th September 1935 as well as several of the meetings of the various expert commissions which preceded the Conference. The discussions of the Conference did not deal with any purely scientific problems but were devoted to arrangements which aim at better collaboration and uniformity in meteorological work in different countries. The long list of resolutions is of great interest to the practical meteorologist. Some items accepted at the conference, and which are of immediate concern to India, are :—

(1) Use of international weather symbols and uniform method of preparing synoptic charts.

(2) A world-wide scheme for the issue of collective synoptic broadcasts in order to fill in the gaps in the existing international issues. In this connection recommendations were made at the Conference for

the Karachi W/T station to begin again the transmission of synoptic data, which was stopped in 1931 as a retrenchment measure.

(3) An amended form of the International Weather Code used on land in tropical regions was accepted.

(4) An amended form of the International Weather Code used by ships in tropical regions was agreed to. This form includes provision for the reporting of state of sea by ships and will be suitable for use in Indian waters.

(5) A new classification of meteorological literature was passed to bring it into line with International Decimal Classification. It was proposed to bring this new classification into general use from January 1, 1936.

(6) The need for publishing all observations that are received day by day from ships was stressed.

(7) Use of radio sondes in upper air research. The Upper Air Commission has resolved to collect and summarise information about the present stage of development of these instruments in different countries.

(8) A world-wide scheme to broadcast climatological data of selected stations once a month. When India participates in this scheme, it will issue data of about 40 selected stations (a message of about 90 words) once a month from Karachi W/T (short wave) station or some other powerful short wave station.

It was decided at the meeting that in future the President of the International Meteorological Committee will give notice of meetings of the conference direct to Governments of the different countries and invite them to send representatives to participate at the meetings; the notices are to be issued a year in advance. It was also decided to create a new commission of "Aeronautical Meteorology" of a slightly different composition from all the other permanent commissions. Its aim will be co-ordination of the work of O. M. I. (*i.e.*, International Meteorological Organisation) with the work of the C. I. N. A. (*i.e.*, International Commission for Air Navigation) and of the regional aeronautical conferences, and in general, the examination of the meteorological problem concerning aeronautics.

The air traffic between India and Siam, Malaya and Indo-China is now both frequent and regular. The exchange of meteorological data with these countries has therefore become a problem of some importance. While Indo-China, Siam and Malaya have started regular broadcasts, India has not yet been able to reciprocate for want of a sufficiently powerful wireless station capable of being heard in Malaya and in China as well as throughout India. Short-wave aeronautical stations are being established at Rangoon and Calcutta and it is expected that when these are completed the problem of exchanging synoptic data with countries to the east and south of Burma will be satisfactorily solved.

Mr. Stewart of the Malayan Meteorological Service paid a short visit to Poona in July 1935 on his way to Europe and views were exchanged on several questions relating to the broadcasting of Indian data for the benefit of Malaya and Siam, Indo-China and the East Indies.

Two officers of the Siamese Navy were deputed by the Government of Siam for training in meteorology in this department. They stayed in India for about 5 months. During this period they were given training in the work of different sections of the Poona Office, and they also visited Karachi, Agra and Calcutta Meteorological Offices. All possible facilities were extended to them during the whole course of their training at the offices of this department.

Concluding Remarks.

The Meteorological Department owes a large part of its usefulness to the sympathetic assistance it receives from other departments. Officers of various Government departments help the meteorological work as honorary superintendents of Observatories or in other capacities. Special mention may be made of the assistance rendered by them in the systematic collection of hail reports from the raingauge stations under them. The India Meteorological Department is greatly indebted to the Imperial Council of Agricultural Research for inaugurating work in Agricultural Meteorology. The department is also very grateful to the Principal of the Agricultural College, Poona, for the facilities given for experimental work at the College farm. The Posts and Telegraphs Department assists this department in the rapid transmission of meteorological information particularly in connection with the warning services.

Weekly telegrams are received from April to October from the Director, Royal Alfred Observatory, Mauritius. These telegrams give valuable information of the weather conditions in the Indian Ocean, and the department is indebted to this observatory for the punctual transmission of the information.

The department is greatly indebted for important information on meteorological conditions prevailing before and during the southwest monsoon to the Controller, Physical Department, Cairo; the Directors of the Observatories at Buenos Ayres and Santiago; the Astronomer Royal, Cape Town; the Director, Department of Agriculture, Zanzibar; the Director, British East African Meteorological Service, Nairobi; the Port Officer Seychelles; the Commonwealth Meteorologist, Melbourne; Director of Agriculture, Salisbury, Rhodesia; Chief of the Weather Bureau, Washington; the Director, Koninklijk Magnetisch und Meteorologisch Observatorium, Batavia, who also arranges kindly for the daily weather telegrams from Sabang in Sumatra.

Thanks are due to the Marine Superintendents of the British India, Peninsular and Oriental, Scindia, Asiatic, Bombay and Persia Steam Navigation companies and the Burma Oil and Indo-Burma Petroleum companies for continuing the arrangement under which many captains of their fleets send weather logs to this department; and to the various ships' officers who sent their marine weather logs direct.

Our thanks are also due to the Superintendent of the Colombo Observatory for the most useful help he has rendered from time to time in connection with storm warning work and for the useful data of Ceylon stations supplied to this department.

C. W. B. NORMAND,
Director General of Observatories.

POONA;

The 29th June 1936.

APPENDIX A.

THE STAFF OF THE INDIA METEOROLOGICAL DEPARTMENT AS IT STOOD ON 31ST MARCH 1936.

METEOROLOGICAL OFFICE, POONA.

Director-General of Observatories.

C. W. B. Normand, M.A., D.Sc. (Edin.).

General Section.

Meteorologist	S. K. Banerji, M.Sc., D.Sc. (Cal.).
Assistant Meteorologist	S. S. Lal, M.Sc., (Lucknow and Lond.), D.I.C. (London), A. Inst.P., F.R.Met.Soc. (temporary).
Superintendent	C. P. Venkataramier, M.A. (Madras).
Assistants	5
Stenographers	4
Cashier	1
Clerks and typists	11

Weather Section.

Meteorologist	S. Basu, M.Sc. (Allahabad).
Assistant Meteorologist	B. N. Sreenivasaiah, M.Sc., (Cal.).
Assistants	2
Clerks and tabulators	13
Draftsmen	5

Observatories Section.

Assistant Meteorologist	Barkat Ali, B.A., M.Sc. (Punjab).
Assistants	2
Inspector of Observatories	1
Clerks	2
Current Weather Observers	8 (at outstations).

Marine Section.

Meteorologist	K. J. Kabraji, B.A. (Hons.) B.Sc. (Bombay), M.Sc., Ph.D. (London).
Assistant	1
Clerk	1

Instruments Section.

Meteorologist	J. M. Sil, B.A., (Cal.), B.Sc., (Engg.), (Boston Tech.).
Assistant Meteorologist	U. N. Ghosh, M.Sc. (Cal.) (Offg.)
Assistants	2
Clerks	5
Draftsman	1
Senior Observers	3
Junior Observer	1
Storekeeper	1
Chief Mechanic	1
Mechanics	3
Carpenter	1

Upper Air Section.

Meteorologist	S. K. Pramanik, M.Sc. (Lucknow), Ph.D. (Lond.) D.I.C.
Assistant Meteorologist	K. Das, M.Sc. (Punjab), Ph.D. (Lond.)
Assistant	1
Clerks	2
Senior Observer	1
Junior Observers	4

Statistical Section and Library.

Meteorologist	S. R. Savur, M.A., (Madras), Ph. D. (Lond.)
Assistant Meteorologist	C. P. Menezes, B.A., B.Sc., (Bombay), (Offg.)
Assistants	3
Librarian	1
Clerks	15
Draftsmen	3

Leave Reserve Meteorologist.

Meteorologist	A. K. Roy, B.Sc. (Cal.) B.A. (Oxon).

Agricultural Meteorology Section.

Agricultural Meteorologist	L. A. Ramdas, M.A., Ph.D. (Calcutta).
Assistant Agricultural Meteorologist	R. J. Kalamkar, B.Sc. (Nagpur) B.Ag. (Nagpur), Ph.D. (London).
Meteorological Assistant	1
Senior Observers	2
Junior Observers	3
Typist	1

Upper Air Observatory, Agra.

Meteorologist-in-charge	G. Chatterjee, M.Sc. (Calcutta).
Meteorologist	N. K. Sur, D.Sc. (Allahabad).
Assistant Meteorologists	A. K. Das, M.Sc. (Cal.) D.Sc. (Paris.)
	S. L. Malurkar, B.Sc. (Mysore), M.Sc.(Cantab.)
	S. P. Venkiteshwaran, B.A. (Hons.), (Madras).
Superintendent	Babu Ram Samnol.
Mechanical Assistant	Chain Sukh.
Chief Observer	1
Chief Computer	1
Foreman	1
Clerks or Observers	43 (at Agra).
Clerks or Observers	72 (outstation staff.)
Mechanics	10
Enginemen	2

Colaba and Alibag Observatories, Bombay.

Meteorologist	K. R. Ramanathan, M A., D.Sc. (Madras).

At Colaba.

Head Clerk	P. A. Salvi, B.A. (Hons.), LL.B. (Offg.)
First Assistant	1
Senior Upper Air Observer	1
Observers	6
Cashier	1
Marine Clerk	1
Typist and Stenographer	1
Junior Upper Air Observer	1

At Alibag.

Observers	2

Alipore Observatory and Meteorological Office, Calcutta.

Meteorologist	S. N. Sen, M.Sc. (Cal. and London.) Ph. D.,(London).
	S. C. Roy, M.Sc.(Cal.), D.Sc. (London) in transit.
Assistant Meteorologists	B. K. Roy, M.Sc.(Cal.)
	S. K. Das, M.Sc. (Dacca & Lond.) D. I.C.,(Lond.) F.R.Met., Soc. (Lond.) (tempy.)
	C. Ramaswamy, M.A.(Hons.), (Madras), (Offg.).

Alipore Observatory and Meteorological Office, Calcutta—concld.

Professional Assistant	N. P. Chatterjee, M.Sc. (Cal.)
Superintendent	T. N. Mitra, B.A., B.L.
Chief Observer	B. B. Roy, M.Sc.
Meteorological Assistants	3 (on Poona Establishment. posted at auxiliary centres.)
Inspector of Observatories	1
Clerks (Upper Division)	5
Stenographer	1
Senior Observers	2
Clerks and Observers (Lower Division)	25
Clerks (Routine Division)	5
Junior Observers	2
Current Weather Observers	5 (at outstations).
Printer. (Press staff)	1

Meteorological Office, Karachi.

Meteorologist	V. V. Sohoni, B.A. (Hons.) M.Sc. (Bombay).
Assistant Meteorologists	B. N. Desai, B.A.,(Hons), LL.B., M.Sc. (Bombay), Ph.D. (Edin.), F.R.S.E.
	S. Mal, M.Sc. (Benares), D. I. C. Ph. D. (Lond.)
Professional Assistant	H. R. Puri, M.Sc. (Punjab).
Meteorological Assistant	1 (on Poona Establishment, posted at auxiliary centre at Jodhpur).
Chief Observer	1
Head Clerk	1
Inspector of Observatories	1
Stenographer	1
Senior Clerks or Observers	4
Clerks or Observers	9
Clerks	5
Junior Clerks or Observers	2
Current Weather Observers	3
Clerk (temporary).	1

Solar Physics Observatory, Kodaikanal.

Director	T. Royds, D.Sc. (London), F.R.A.S. [on deputation to Eclipse Expedition 1936 (Japan) from 24th March 1936.]
Assistant Director	A. L. Narayan, M.A., D.Sc., (Madras), F.I.P.
Assistants	3
Recorders	4
Mechanic	1
Book-binder	1

Meteorological Office, No. 3(Indian) Wing, R. A. F., Quetta, temporarily transferred to Karachi.

Meteorologist	P. R. Krishna Rao, B.Sc. (Mysore) (temporary).
Sénior Clerk (temporary)	1
Junior Clerks	1

Meteorological Office, No. 1(Indian) Group Headquarters, R. A. F., Peshawar.

Meteorlogical Officer (R. A. F.)	F./Lt. L. H. Starr.
Senior Clerk (temporary)	1
Junior Clerks and Observers	4

Lahore Observatory.

Chief Observer	1
Clerks or Observers	3

Madras Observatory.

Assistant-in-charge	1
Senior Observer	1
Junior Observers	2

Officer on leave.

V. Doraiswamy Iyer, B.A. (Madras).

APPENDIX B.

PUBLICATIONS.

The following departmental publications were *issued or sent* to press during the year :—

I. *Periodical.*

1. Daily weather Reports—
   - i. Indian Daily Weather Report.
   - ii. Calcutta Daily Weather Report.
   - iii. Karachi Daily Weather Report.
2. Weekly Weather Report.
3. India Weather Review, Monthly Weather Report.
4. India Weather Review, Annual Summary, 1934, in five parts—
   - i. Introduction.
   - ii. Part A.—Summary of Weather and Rainfall and Tables.
   - iii. Part B.—Snowfall.
   - iv. Part C.—Storms and Depressions.
   - v. Part D.—Seismic Records.
5. Daily Rainfall of India for 1933.
6. Monthly Rainfall of India for 1933.
7. Upper Air Data, 1934, in 14 parts:—
   - i. Parts 1—12.—Pilot Balloon and Aeroplane Data for January to December.
   - ii. Part 13.—Monthly Means of Pilot Balloon Data and Monthly Frequencies of Clouds.
   - iii. Part 14.—Sounding Balloon Data.
8. Seasonal Memoranda—
   - i. Memorandum on the Probable character of winter precipitation in North-West India (January—March 1936).
   - ii. Statement of the rainfall and snowfall of North-West India in January, February and March 1935 and a comparison of the seasonal forecast with the actual precipitation.
   - iii. Memorandum regarding the probable amount of monsoon rainfall in 1935.
   - iv. Memorandum on the rainfall of June and July and the probable amount during August ond September 1935.
   - v. Statement of the actual rainfall in the monsoon season, June to September, 1935, and a comparison of the forecast with the actual rainfall.
9. Magnetic, Meteorological and Seismographic Observations made at the Government Observatories, Bombay and Alibag, in the year 1933.
10. Report on the Administration of the Meteorological Department of the Government of India in 1934-35.
11. Annual Report of the Kodaikanal Observatory, 1935.

II.—*Occasional.*

1. Memoirs of the Indian Meteorological Department:—

Vol. XXVI—

Part V.—Soundings of temperature and Humidity in the Field of a Tropical Cyclone and a Discussion of its Structure by K. R. Ramanathan, M.A., D.Sc.

Part VI.—Typhoons and Indian Weather by V. Doraiswamy Iyer, B.A.

2. Scientific Notes:—

Vol. VI—

No. 67.—Measurement of Vertical Currents in the Atmosphere, mainly of Thermal Origin, with Pilot Balloons by K. R. Ramanathan and K. P. Ramakrishnan.

No. 68.—Hourly Rainfall at Lahore by V. Doraiswamy Iyer, B.A., and V. Lakshminarasimhan, B.A.

Vol. VII—

No. 69.—A Statistical Analysis of the Distribution of the South-West Monsoon Rainfall at Akola by V. Satakopan, M.A.

No. 70.—A Study of Correlation Coefficients of Mean Maximum Temperatures, between Successive Months, at a few Selected stations in India by R. J. Kalamkar, B.Sc., B.Ag., Ph.D..

3. Kodaikanal Observatory Bulletins:—

CVI.—Summary of Prominence Observations for the second half of the year 1934.

CVII.—Oxygen in the Sun's Chromosphere.

4. Meteorology for Airmen:—

Part I.—General Meteorological Features.

Part II.—The Climatology of Air Routes.

5. Catalogue of Periodicals in the Libraries of the Department.

The following papers or notes were contributed to extra departmental journals:—

1. Banerji, S. K.—

Theory of Microseisms, Pro. of the Ind. Acad. of Sciences, Section A, Vol. I, 1935, pp. 727—753.

Hydraulic Seismographs, Current Science, Vol. III, 1935, pp. 532—536.

2. Das, A. K.—

The Atmosphere of the Earth, Its Evolution and Properties, Journal of Department of Science, Calcutta University, 1935, pp. 1—19.

The Physical Constitution of the body of the Earth, Journal of Department of Science, Calcutta University, 1935, pp. 20—35.

The Evolution of Climate through Geological Times, Journal of Department of Science, Calcutta University, 1935, pp. 36—49.

Nova Herculis and Cosmic Rays, Nature Vol. 136, 1935, pp. 29—30.

3. Kalamkar, R. J.—

Influence of weather and prices on the Cotton Crop of the Bombay Presidency,—Current Science, Vol. 4, 1936, pp. 484—486.

—— and Singh, S.—

A Statistical Examination of the yield of wheat at the Cawnpore Agricultural College Farm, Part I. Indian Journal of Agricultural Science, Vol. 5, 1935, pp. 346—354.

—— and Gadre, K. M.—

Precision observations on weather and Crops, Current Science, Vol. 4, 1936, pp. 645—646.

4. Narayan, A. L. and Royds, T.—

Oxygen in Solar Prominences, Current Science, Vol. 4, 1936, p. 734.

5. Raman, P. K.—

Heat Radiation from the Clear Atmosphere at Night, Pro. Ind. Acad. of Sciences, Vol. 1, 1935, pp. 815—821.

Measurement of the Transmission of Heat by Convection from Isolated ground to the Atmosphere, Pro. Ind. Acad. of Sciences, Vol. 3, 1936, pp. 98—106.

6. Ramanathan, K. R.—

Exploration of the Upper Air by means of Sound Waves, Current Science, Vol. 4, 1936, pp. 140—142.

—— and Ramdas, L. A.—

Derivation of Angstrom's formula for Atmospheric radiation and some general Considerations regarding nocturnal Cooling of Air layers near the ground. Pro. Ind. Acad. of Sciences, Vol. 1, 1935, pp. 822—829.

7. Ramdas, L. A. and Katti, M. S.—

The Diurnal variation of Moisture in the Soil during the Clear season, Current Science, Vol. 3, 1935, p. 419.

—— and Paranjpye, M. K.—

An Interferometric Method of Measuring Temperature and Temperature gradients very close to hot surface, Current Science, 4, 1936, pp. 642—644.

8. Roy, S. C.—

A note on the Baluchistan Earthquake of May 31, 1935, Current Science, Vol. III, 1935, pp. 597—599.

9. Royds, T.—

Oxygen in the Sun's Chromosphere, Nature, Vol. 136, 1935, pp. 606-607.

10. Savur, S. R.—

Application of the Performance Test to Seasonal Forecasting of Rainfall in India, Sankhya (Indian Journal of Statistics), Vol. II, 1935, pp. 2—12.

A simple test of value of a Particular Period in Forecasting, Pro. of the Ind. Acad. of Sciences, Vol. II, 1935, pp. 336—341.

GIPD—L142 DGofObs. Poona—21-10-36—550.

DGO. 26.37.
550

Report on the Administration of the Meteorological Department of the Government of India in 1936-37.

PUBLISHED BY THE MANAGER OF PUBLICATIONS, DELHI.
PRINTED BY THE MANAGER, GOVERNMENT OF INDIA PRESS, NEW DELHI.
1937.
Price Annas 14 or 1s. 6d.

INDIA METEOROLOGICAL DEPARTMENT.
POONA 5. (INDIA).

With the Compliments

of the

Director General of Observatories.

O. B. S. 290.

LIBRARY OF THE BOMBAY BRANCH OF THE ROYAL ASIATIC SOCIETY

Report on the Administration of the Meteorological Department of the Government of India in 1936-37.

PUBLISHED BY THE MANAGER OF PUBLICATIONS, DELHI.
PRINTED BY THE MANAGER, GOVERNMENT OF INDIA PRESS, NEW DELHI.
1937.

List of Agents in India from whom Government of India Publications are available.

(*a*) PROVINCIAL GOVERNMENT BOOK DEPOTS.

MADRAS:—Superintendent, Government Press, Mount Road, Madras.
BOMBAY:—Superintendent, Government Printing and Stationery, Queen's Road, Bombay.
SIND:—Manager, Sind Government Book Depot and Record Office, Karachi (Sadar).
UNITED PROVINCES:—Superintendent, Government Press, Allahabad.
PUNJAB:—Superintendent, Government Printing, Punjab, Lahore.
CENTRAL PROVINCES:—Superintendent, Government Printing, Central Provinces, Nagpur.
ASSAM:—Superintendent, Assam Secretariat Press, Shillong.
BIHAR:—Superintendent, Government Printing, P. O. Gulzarbagh, Patna.
NORTH-WEST FRONTIER PROVINCE:—Manager, Government Printing and Stationery, Peshawar.
ORISSA:—Press Officer, Secretariat, Cuttack.

(*b*) PRIVATE BOOK-SELLERS.

Advani Brothers, P. O. Box 100, Cawnpore.
Aero Stores, Karachi.*
Banthiya & Co., Ltd., Station Road, Ajmer.
Bengal Flying Club, Dum Dum Cantt.*
Bhatia Book Depot, Saddar Bazar, Ranikhet.
Bhawnani & Sons, New Delhi.
Book Company, Calcutta.
Booklover's Resort, Talkad, Trivandrum, South India.
Burma Book Club, Ltd., Rangoon.
Butterworth & Co. (India), Ltd., Calcutta.
Careers, Mohini Road, Lahore.
Chatterjee & Co., 3, Bacharam Chatterjee Lane, Calcutta.
Chukervertty, Chatterjee & Co., Ltd., 13, College Square, Calcutta.
City Book Club, 98, Phayre Street, Rangoon.
Das Gupta & Co., 54/3, College Street, Calcutta.
Delhi and U. P. Flying Club, Ltd., Delhi.*
English Book Depot, Ferozepore.
English Book Depot, Taj Road, Agra.
English Bookstall, Karachi.
English Book Store, Abbottabad, N.-W. F. P.
Faqir Chand Marwah, Peshawar Cantt.
Fono Book Agency, Simla.
Gautama Brothers & Co., Ltd., Meston Road, Cawnpore.
Higginbothams, Madras.
Hindu Library, 137-F., Balaram De Street, Calcutta.
Hyderabad Book Depot, Chaderghat, Hyderabad (Deccan).
Imperial Book Depot and Press, near Jama Masjid (Machhliwalan), Delhi.
Indian Army Book Depot, Dayalbagh, Agra.
Indian Army Book Depot, Daryaganj, Delhi.
Indian Book Shop, Benares City.
Indian School Supply Depot, Central Avenue, South, P. O. Dharamtala, Calcutta.
Insurance Publicity Co., Ltd., Lahore.
International Book Service, Poona 4.
Jacques & Co., Kamptee Road, Nagpur, Messrs. Neston.
Jaina & Bros., Mori Gate, Delhi and Connaught Place, New Delhi, Messrs. J. M.
Kamala Book Depot, 15, College Square, Calcutta.
Karnataka Publishing House, Bangalore City.
Keale & Co., Karachi.
Keshao Book Stall, Khadibazar, Belgaum.
Kitabistan, 17-A, City Road, Allahabad.
Krishnaswami & Co., Teppakulam P. O., Trichinopoly Fort, Messrs. S.
Lahiri & Co., Calcutta, Messrs. S. K.
Local Self-Govt. Institute, Bombay.
London Book Co. (India), Arbab Road, Peshawar, Murree, Nowshera, Rawalpindi.
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Malik & Sons, Sialkot City.
Mathur B. S., Bookseller, Civil Lines, Jodhpur.
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Raghunath Prasad & Sons, Patna City.
Rama Krishna & Sons, Booksellers, Anarkali, Lahore.
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Ray & Sons, 43, K. & L. Edwardes Road, Rawalpindi, Murree and Peshawar, Messrs. J.
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Thacker & Co., Ltd., Bombay.
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University Book Agency, Kacheri Road, Lahore.
Upper India Publishing House, Ltd., Literature Palace, Ammuddaula Park, Lucknow.
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Wheeler & Co., Allahabad, Calcutta and Bombay. Messrs. A. H.
Young Man & Co., (Regd.), Egerton Road, Delhi.

* Agent for publications on Aviation only.

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Report on the Administration of the Meteorological Department of the Government of India in 1936-37.

I.—CHIEF FEATURES OF THE YEAR.

1. The chief features of the work during the year are summarised in the following paragraphs. Fuller details are given in the subsequent chapters. The main items were—(1) an improvement in the meteorological organisation along the air routes to meet additional demands on account of increased frequency in flying including night flying, (2) the help given to establish an independent meteorological service in Burma, (3) examination of certain deficiencies in the meteorological organisation from the point of view of safety in flying, both civil and military, the discussion of these by a representative conference and formulation of definite recommendations, (4) adoption of many of the resolutions passed at the International Meteorological Conference and the International Commission for Aerial Navigation at Warsaw, [illegible] and (5) proposal to provide at the Headquarters Office at Poona a second daily weather chart and a short-wave wireless station and to meet the extra cost by reducing other telegraphic expenditure.

2. **Improvement in services to aviation.**—Among the various results of the steady increase of air traffic over India, it is not surprising to find a steady demand by airmen for more and more weather reports. The provision of better facilities for reporting weather along air-routes had once more, therefore, to receive attention during the year. As aeroplanes will soon be flying by night as well as by day, experimental work had to be undertaken in readiness for that event, including the standardisation of equipment for observing balloons at night and measuring visibility and height of cloud; the wireless watch periods along the trans-India route were modified to allow reports of upper winds and weather to be wirelessed before dawn each day; and Government sanctioned extra staff for night-work at eight stations (Karachi, Jodhpur, Delhi, Allahabad, Gaya, Calcutta, Jacobabad, Bombay), on the air-routes as well as new pilot-balloon stations at Delhi and Trichinopoly to observe upper winds. Routine arrangements for reporting current weather were extended to six more stations (Bahrein, Sharjah, Gwador, Barmer, Asansol and Henzada). The weather reports to be supplied to airmen on the new seaplane route were discussed, and so also was the possibility of providing more frequent forecasts from Poona. It is well known that 4 to 6 weather charts are prepared each day at forecasting centres in many other countries; but these systems are expensive and financial considerations have limited Poona's charts in the past to one a day. Accordingly it was proposed to give up the check figures in the coded message for transmission of daily observations from observatories, to adopt the cheaper 8-word telegram, and to utilise a large part of the savings to provide at the Headquarters Office

at Poona a second weather chart and so make evening forecasts available there. It was proposed to utilise the remainder of the savings to provide a short-wave wireless station at Poona for quick intercommunication between the different forecasting offices, to ease the distribution of weather reports for aviation and to enable India better to participate in the international diffusion of weather data, both daily and monthly. The proposal for the evening chart was sanctioned with effect from 1st April, 1937.

3. **Conference at Delhi.**—At the instance of the Royal Air Force a conference was held at Delhi in December, 1936, to consider what additional meteorological facilities were necessary for safety in flying, both civil and military. Amongst the recommendations of the conference were (i) the reopening of a forecasting office at Delhi, (ii) starting of an aviation section at Poona, (iii) the establishment of a few additional reporting observatories along the air routes and the north-west frontier and (iv) the creation of two posts of Meteorological Assistants for the meteorological offices at Peshawar and Quetta. These recommendations were examined in detail in preparation for formal proposals to Government.

4. **Meteorological Service in Burma.**—The Government of Burma decided to start an independent meteorological service on the separation of that Province from India. The scheme, which was drafted at Poona, involved the revival of a meteorological office at Rangoon. The Government of India, at Burma's request, agreed to send three gazetted meteorological officers on deputation to Burma; and steps were taken to fill up the existing posts of meteorological assistants and observers in Burma by members of the staff who volunteered for service in that country.

5. **Mount Everest Expedition of 1936.**—Assistance was rendered to the Mount Everest Expedition of 1936 by providing special weather reports and forecasts to the Party through their radio station at Darjeeling. Weather reports were also furnished to the base camp at Skardu of the French Karakorum Expedition and to the participants in the Paris-Saigon-Paris air race.

6. **International Conferences and obligations.**—The hundred and more resolutions which were passed by the International Meteorological Conference at Warsaw were examined in detail. The changes in the specification of the codes as recommended by the conference were adopted in full, and so also was the new form of international ships' code for the tropics. Of the many other recommendations of the conference some have been adopted and some are still under consideration. The need for exchange of weather reports with neighbouring countries continued to be keenly felt, and fortunately it was possible to arrive at provisional decisions to begin regular broadcasts early next year of meteorological data from the short-wave aeronautical wireless stations at Rangoon, Calcutta and Karachi and also at Delhi when the forecasting office is reopened at that station. It is hoped that these

will be heard by neighbouring countries and some of the meteorological broadcasts from neighbouring countries will also be received here. This arrangement will enable the various meteorological services to draw weather maps for the whole of South Asia—an improvement which has been awaited for a number of years, and one which will lead to a clearer understanding of weather changes over this part of the globe. This international exchange of data was amongst the subjects discussed at Hongkong in January, 1937, by the Meteorological Commission for the Extreme Orient which Mr. S. Basu of this department attended, and at which questions of common interest to weather services in the Far East filled the agenda.

7. Dr. T. Royds, Director, Kodaikanal Observatory, proceeded to Japan on deputation to observe the total eclipse of the sun and was fortunate in getting some successful and important photographs almost right up to the moment of totality, when clouds intervened.

8. **Seismological Section.**—The committee appointed by the Government of India, which consisted of the Surveyor General, the Director of the Geological Survey of India, and the Director General of Observatories, had reported during the previous year that a Seismological Section should be established under a whole-time seismologist with a small subordinate gazetted and non-gazetted staff and that some additional observatories should be set up, mainly along the earthquake zone. This proposal received the approval of the Government of India, but for financial reasons the scheme was deferred.

9. **Routine activities.**—The department carried on its marine and inland warning work and other normal activities at the various centres. An important addition was made to the warning work of the department at the instance of the Imperial Council of Agricultural Research and the Government of Bombay; this related to the issue of warnings to the provincial authorities regarding incidence of frosts and heavy and untimely rainfall. According to reports received from district officers, these warnings have in general been timely and of some use, but the main difficulty has been to make the information quickly available to the large body of agriculturists. The full advantage of such a service will be gained only when every village has a wireless receiver, and dissemination is made by wireless. Some improvement was effected in the arrangements for forecasting at the Royal Air Force Meteorological Offices at Peshawar and Quetta, by providing them with better weather charts. The all-India Weather Summary telegram ceased to be supplied except to press subscribers; and the needs of other subscribers were met by four regional weather summary telegrams, giving the chief weather features for Peninsular India, northern and central India, north-west India, and north-east India and Burma respectively.

10. **Investigations.**—A fair amount of progress was maintained in investigational work in meteorology. 90 sounding balloons were released from Agra, 26 from Poona and 22 from Madras. Measurements of cosmic ray intensity and of the horizontal transmission co-efficient of

the atmosphere was begun at Agra. At Kodaikanal a photometric study was made of the calcium and hydrogen lines at different points of the Sun's disc, and at Bombay the day-to-day variability of the horizontal force of the earth's magnetic field and also of the earth-air current from elevated points during thundery weather were studied. At Poona the detailed distribution of rainfall in South India was examined, and statistical work to improve the existing forecasting formulæ was continued. In addition to several papers communicated to outside journals one Memoir and three Scientific Notes were sent to the Government of India press for printing.

11. **Agricultural Meteorology.**—The Agricultural Meteorology section carried on its investigation of the local climates and growth-rates of crops, the thermal and moisture balance at the surface of the ground, control of soil temperature, etc., and also on frequencies of hail, droughts, floods, and cold and heat waves. The Imperial Council of Agricultural Research passed a resolution to the effect that Agricultural Meteorology should become one of the permanent activities of Government. Formal proposals for making the section permanent are now under the consideration of the Government of India.

12. **Warning messages.**—The number of weather forecasts issued to aircraft from the different forecasting centres totalled more than 8,000. Besides these more than 7,000 reports on current weather and adverse weather and improvement thereof were supplied to pilots from different stations along the air routes.

Nearly 10,000 warning messages were issued to ports in connection with disturbed weather on the seas, and the warning messages of inland heavy rainfall, untimely rainfall, high winds and frosts numbered several thousands.

13. **New Buildings.**—Some progress was made in the meteorological building programme at the aerodromes under the Capital Expenditure Scheme. The buildings at the Gaya aerodrome became ready for occupation and the Pilot Balloon Observatory was shifted from Patna to that station. On the necessary accommodation becoming available, the pilot balloon observatory at Colaba (Bombay) was shifted to Juhu aerodrome.

14. **Plans and Projects.**—Possible new lines of advance without appreciable increase in the total budget of the department received much attention during the year. The rapidly growing demands of aviation and the ever increasing technical and administrative questions required to be dealt with in that connection have made the establishment of an aviation section and some reorganisation of the supervising staff a pressing necessity. Regular observations of upper air temperatures by special aeroplane ascents at all important aerodromes or aero clubs are needed to ensure greater accuracy in the forecasting of thunderstorms and, other convectional phenomena, while intensive upper air surveys during the passage of storms and depressions, and in general an increasing activity in upper air research are other desirable items to be undertaken as soon as funds become available.

II.—MARINE METEOROLOGY.

Storm Warnings.—No change was introduced in the system of storm warnings for ports and shipping during the year under report. Storm warnings for the Bay of Bengal and the surrounding areas continued to be issued from the Calcutta Meteorological Office and those for the Arabian Sea area from the Poona Meteorological Office. The number of ports on the warning list was 39 on the west coast of India and 34 round the Bay of Bengal. The latest weather information was supplied as usual to shipping at sea by means of wireless weather bulletins issued twice daily from the coastal radio stations on ordinary undisturbed days and more frequently on days of disturbed weather. At the request of the Flag Officer Commanding, Royal Indian Navy, copies of messages issued daily for broadcasting from the coastal radio stations at Bombay and Karachi were sent to the Navy Wireless station, Bombay, for being broadcast therefrom for the benefit of the ships belonging to the Royal Indian Navy. This arrangement has been agreed to as a routine measure.

The total number of broadcast messages issued by the Calcutta Office during the year was 1,859 as against 1,725 in the previous year, and the number issued by the Poona Meteorological Office was 1,267 against 1,069 during the previous year.

Services to ports around the Bay of Bengal.—Warnings were issued by the Meteorological Office, Calcutta, for 40 periods of disturbed or suspicious weather and probability of thundersqualls. Of these, 15 developed into depressions, of which 5 intensified further into cyclonic storms. Three of the storms, which occurred in April, May and October were severe in intensity and caused great havoc in Arakan, East Bengal and the north Madras Coast respectively. An account of the damage caused by the Arakan storm is reproduced below from a statement issued by the Commissioner of Arakan Division and President of the south Arakan Cyclone Relief Committee—

> "The storm of April 26, was unprecedented in its severity. Its centre crossed the coast, by way of Cheduba Island, where Sandoway and Kyaukpyu districts meet, causing enormous havoc throughout the 40-mile width of its track.
>
> * * * * *
>
> The pressure of the wind, helped by rising tide, caused a tidal wave which reached the very foot hills of the main coastal range. Where it crossed the coastline, the height of the wave was 16 feet above ordinary high-water-mark and all the flat low-lying islands were submerged to a depth of 12 feet or more. In such places, the villagers and their cattle had little chance of escape and were trapped and drowned in scores.

So strong was the wind that every tree in the region was stripped of all its leaves and palm trees were snapped in half. Even the strongest swimmers were beaten down and drowned. On higher land, houses and granaries were swept away by the wind like straw and the torrential rain destroyed all the grain which the villagers had stored for their own consumption until next harvest in December, as well as the grain required for sowing at the present season. Cattle were panic-striken and great numbers were drowned by rushing headlong into the swollen creeks.

Altogether, over 1,000 people were drowned or killed by falling trees and 30,000 homesteads destroyed with all their contents. About 8,000 head of cattle were lost and some thousands of acres of rice fields were damaged by salt water. Numbers of fishing craft were destroyed and wells made unfit for use".

The usual circular letters were issued to the port authorities asking for their opinions regarding the warnings issued to them during the year. Nearly all of them expressed satisfaction with the warnings received by them. Suggestions or criticisms on individual warnings issued and other remarks offered by the port authorities are always welcomed by the department as these help to improve the organisation and service by drawing attention to directions in which improvement is desired by recipients of the warnings. The total number of warnings issued to ports by the Calcutta Office was 5,230 as against 3,658 in the previous year.

Services to Arabian Sea Ports.—Warnings for disturbed weather were issued by the Meteorological Office, Poona, on 30 occasions. Of these one developed into a storm and one into deep depression.

Thirty-two Port Officers sent in their annual returns about the warnings issued to them. Most of them stated that the warnings were timely and satisfactory in every respect and that no change in the present system was necessary. The number of warning messages issued to ports by the Meteorological Office, Poona, was 4,380 during the period under report as against 2,277 in the previous year.

Exchange of information with ships at sea.—The chief sources of marine data are wireless weather messages from ships at sea and extracts from weather logs of ships calling at the principal ports of India and Burma. During the year 9,992 messages were received from ships in the Bay and the Arabian Sea as against 9,176 received during the previous year. The figures indicate satisfactory co-operation between ships' captains and this department. It is not possible to name here every steamship that sent messages but those that sent 50 messages or more

during the year are listed below along with the number of messages received from each :—

Name.	Number of messages.	Name.	Number of messages.
1. Aungban	159	26. Jaladurga	55
2. Alavi	111	27. Jalatarang	174
3. Binfield	54	28. Jaladuta	85
4. Badarpur	153	29. Jalaratna	54
5. British Soldier	51	30. Jalajyoti	58
6. British Sailor	92	31. Johan van Oldenbarnevelt	59
7. British Sovereign	128	32. Karagola	85
8. Baloeran	76	33. Khosrou	210
9. Chyebassa	89	34. Karapara	73
10. Chilka	109	35. Khandalla	61
11. Cathay	52	36. Karoa	84
12. Conte Verde	50	37. Maharaja	100
13. Elephanta	54	38. Masimpur	50
14. Ellenga	65	39. Mooltan	55
15. Ethiopia	147	40. Rajula	64
16. Egra	78	41. Rohna	66
17. Ekma	90	42. Rahmani	52
18. Erinpura	138	43. Singu	140
19. Golconda	72	44. Strathmore	54
20. Hosang	61	45. Tanfield	58
21. Jalavijaya	93	46. Talamba	57
22. Jalapalaka	74	47. Winkfield	78
23. Jalavihar	72	48. Warina	60
24. Jalaputra	55		
25. Jalapadma	64		

Pilot balloon messages were received by wireless occasionally from H. M. I. S. Investigator and the H. M. ships Enterprise, Dorsetshire, Emerald, Deptford, Norfolk, and were found to be very valuable.

The second principal source of marine data is the log extracts collected by marine clerks in Calcutta and Bombay and the various steamship agencies. The Port authorities at Rangoon also continued to render help by allowing the observers of the Time Ball and Tidal Observatory to collect ships' data. Occasionally, in cases of specially important disturbed weather, logs of steamers were collected with the help of the Colombo Port authorities. The British India, the Peninsular and Oriental, the Scindia, the Asiatic, the Bombay and the Persia Steam Navigation Companies, and the Burma Oil, the Anglo-Iranian Oil and the Indo-Burma Petroleum Companies have standing arrangements with a number of their ships' Captains to copy and despatch extracts from weather logs on two kinds of forms, which are supplied to them

for use during ordinary weather and during disturbed weather respectively. A total of about 4,000 logs was collected during the year.

Synoptic data for ships' use.—In accordance with the scheme introduced last year, synoptic data of selected Indian stations were wirelessed throughout the year under report from the coastal radio stations at Calcutta, Bombay and Matara for the benefit of shipping in the Indian waters. In order to increase the usefulness of these data for purposes of preparation of weather charts by the ships, the inclusion of the synoptic data of a few ships in selected positions in the Indian waters was also arranged for during the year.

III.—AVIATION METEOROLOGY.

The meteorological offices at Karachi and Calcutta continued to be responsible for the supply of weather reports and forecasts to aviators on the main trans-India route. The Peshawar Office and the Quetta Office (temporarily located at Karachi) continued as usual to supply weather reports and forecasts to the Royal Air Force pilots. The Poona Office issued forecasts to aircraft in South India, including the Tata Air Mail Service between Ahmedabad and Madras and between Bombay and Trivandrum. Besides weather reports and forecasts to the regular air mail services, route forecasts and reports were supplied on requisition to various individual fliers, members of the Indian Flying Clubs and Royal Air Force Flying Squadrons. In connection with the air route development scheme, the additional facilities sanctioned early in the year for the trans-India route were the establishment of an auxiliary centre and pilot balloon station at Delhi and the provision of extra staff at pilot balloon stations on the Karachi-Calcutta section to enable these stations to keep a longer watch, take extra current weather observations and let off and observe a pilot balloon at night. On the Karachi-Lahore route, extra staff was sanctioned for Jacobabad for an additional pilot balloon ascent at night and an 8-hour watch daily. The establishment of an auxiliary centre at Juhu and pilot balloon station at Trichinopoly was sanctioned for the Karachi-Colombo route. The department busied itself in getting the additional facilities to work as early as possible, and as aeroplanes would soon be flying by night as well as by day, preliminary experimental work was undertaken, in readiness for that event, in connection with the standardisation of equipment for observing balloons and measuring visibility and cloud height at night and other allied problems. Action for the supply and early installation of necessary instruments was also taken. Detailed instructions were drawn up and issued to observers for determining visibilities and cloud heights by night, and pilot balloon observers were trained in night balloon work.

With the sanction of extra staff, the number of current weather observations exchanged daily by wireless on the Karachi-Calcutta route

was increased from 2 to 3, one of these observations being taken and wirelessed before dawn for the benefit of airmen leaving terminal stations early in the morning.

Arrangements were also made at pilot balloon stations on the Karachi-Calcutta route to have an extra pilot balloon ascent at 0330 I. S. T. and furnish the data along with the early morning current weather observations. The schedules of current weather and pilot balloon observations were suitably revised, and the wireless watch periods along the trans-India route modified in order to fit in with these revised schedules. An extra balloon ascent at 0330 hours I. S. T. was also arranged at Jacobabad on the Karachi-Lahore route, and arrangements made to supply the data to the I. N. A. machines. In addition to these improvements in the routine scheme, arrangements were made for certain special observations on flying days of the Imperial Airways. These special observations consisted of an early morning current weather observation at Akyab and Chittagong for the use of east bound planes leaving Dum Dum, a midday pilot balloon ascent at Akyab for the use of the west bound plane leaving Rangoon and an early morning pilot balloon ascent at Sherjah. With the co-operation of the Imperial Airways, a restricted scheme of current weather reports on flying days of their planes was introduced at Bahrein, Sherjah and Gwador. Arrangements were also made for current weather reports from Barmer, Asansol and Henzada to be transmitted to Karachi, Calcutta and Bassein W/T stations respectively for further distribution by W/T along the trans-India chain.

Steps were taken for the training of the civil aviation personnel at certain emergency landing grounds in sending reports of dangerous phenomena and their improvement. The question of special facilities required in connection with sea-plane route across India was also discussed and proposals for immediate requirements put up to Government for sanction. A conference at Gwador between the representatives of the Air Ministry and the Imperial Airways and of the Meteorological, Aviation, Telegraph and Public Works Departments considered the question of future development of the ground organisation at Gwador as a part of the Empire Air Routes development scheme. The Meteorologist, Karachi, represented this department at the conference.

The meteorological buildings on the Gaya aerodrome became ready towards the end of the year, and the pilot balloon observatory was shifted from Patna to Gaya. Pilot balloon and current weather observations were started at Gaya in March, 1937. Necessary accommodation being made available on the Juhu aerodrome, the pilot balloon observatory at Colaba was shifted to Juhu in January, 1937. Arrangements were made at Gwador for special visibility reports relating to the aerodrome, which is at some distance from the observatory, to be issued as additional messages on flying days of the Imperial Airways whenever visibility conditions became bad. Arrangements were made for the

issue of current weather reports from Dum Dum aerodrome instead of from the Alipore observatory on as many occasions as possible.

Symbols and specifications of the elements reported in the aviation codes were revised in the light of international resolutions passed at Warsaw.

Specifications of the NEWSMET message were revised during the year. According to the new arrangements the NEWSMET issued at night covers a period of 16 hours, *i.e.*, from 22 hours I. S. T. to 14 hours I. S. T. of the next day, while the noon NEWSMET covers a period of 8 hours from 14 hours I. S. T. to 22 hours I. S. T.

Of special flights for which meteorological facilities were provided may be mentioned the Paris-Saigon-Paris air race, the flights of H. E. the Governor of Sind and the Hon'ble Member-in-charge of the Department of Industries and Labour, and the "Good will flight" between Japan and England of the Japanese plane "Divine wind".

As in previous years, the department arranged for the training and examination in elementary meteorology of candidates for pilots' B licence. Personal contact between pilots and meteorological staff was encouraged and arrangements were made for a member of the meteorological staff to be present as often as possible at the aerodromes on flying days in order to meet the pilots and discuss weather matters with them. Such contact is sure to lead to a better understanding, on both sides, of the problems and difficulties and to an improvement in the standard of the service. Special instructions were also issued to meteorological personnel along the air routes with a view to achieve closer co-operation and understanding between the meteorological staff on the one hand and the aviation and wireless personnel on the other. Of other important matters relating to aviation may be mentioned the introduction of the 'AERMET' Scheme according to which aircraft in flight take observations of weather, particularly during monsoon or other difficult weather, and transmit them by wireless for the benefit of other aircraft and of forecasting centres. Nearly a hundred AERMET messages were received during the year.

On the whole the organisation worked satisfactorily during the year. A few complaints were received relating to the absence of sufficient details in certain forecasts; these were investigated and attempts made to meet them as far as the present organisation would allow. The introduction of night balloon flights have, to a large extent, met complaints about late receipt of upper winds.

The following is an extract from the report of Flight of 230 Squadron from Pembroke Dock to Rangoon—October-November, 1936 :—

> "The Civil Meteorological Service in India was particularly good. Forecasts received from them were most accurate and the staff went to considerable trouble to render every possible assistance."

The total number of aviation forecasts—as distinct from aviation weather reports—issued during the year was 8,141, of which Karachi was responsible for 3,942, Calcutta for 3,075, Poona for 770, Peshawar for 163 and R. A. F. Meteorological Office, Karachi, for 234. The number of special current weather reports and voluntary warnings of adverse weather and improvement thereof issued by observers along the chain of current weather stations is given below :—

Name of Station.	Number of special current weather reports supplied.	Number of DANMET and IMPMET messages issued.
1. Bahrein	239	17
2. Sherjah	99	80
3. Gwador	39	74
4. Karachi	453	91
5. Jodhpur	370	26
6. Delhi	118	60
7. Allahabad	365	24
8. Calcutta—		
(*a*) Alipore	456	210
(*b*) Dum Dum	84	31
9. Chittagong	392	53
10. Akyab	539	103
11. Sandoway	365	54
12. Bassein	400	16
13. Rangoon	711	33
14. Tavoy	70	6
15. Victoria Point	268	14

In addition to the above, 1,313 current weather reports were supplied by observatories on the Ahmedabad-Madras route to the Tata Air Mail Service. Appreciable use was made by airmen of the Q code for obtaining meteorological information.

New editions of the pamphlets "Meteorological Organisation for Airmen" and "Aviation Weather Codes" and of the Pocket Card of Aviation Weather Codes were prepared.

IV.—SQUALL, HEAVY RAINFALL, AND FROST WARNINGS.

Inland weather warnings and forecasts.—The majority of officers to whom warnings of heavy rain and strong winds on land were issued from Poona, Calcutta and Karachi, were district officers and officers of the Irrigation, Railway, Police, Telegraphs and other departments. In addition to these, the departmental warning lists also contained agricultural interests who require to be warned of conditions favourable for occurrence of frost. The number of officers on the Poona warning list was 185 and on the Karachi list 12. The number of officers on the Calcutta warning list was 150, including 12 officers of the Telegraph Department, 8 river ports, 13 river stations and 58 police stations. In addition to these, 415 district and police officers in Bengal received only "Great Danger Warnings" from the Calcutta Meteorological Office. Apart from these specific warnings to individual officers, the Daily Weather Telegraphic Weather Summaries contain heavy rainfall and cold wave forecasts, and all subscribers thereto and others to whom the information becomes accessible thus receive these warnings. In addition to warnings sent to those on the standing lists referred to above, warnings were also issued in response to special requisitions.

Important additions to the inland warning work of the department took place during the year at the instance of the Imperial Council of Agricultural Research and of the Government of Bombay. One of the schemes aims, by the issue of timely warnings to the areas concerned, to minimise damage to crops by frost. There are at present 34 agricultural officers on the low temperature warning list, and the areas represented by them cover the Deccan, the central parts of the country, Bihar, the United Provinces and the whole of northwest India excluding Sind and Kashmir. Special warning telegrams were sent from Poona to these officers whenever low temperatures below a certain limit, fixed with special reference to the conditions in each area, were anticipated. According to the second scheme introduced at the instance of the Bombay Government, Collectors and Deputy Directors of Agriculture in the Presidency were warned against heavy or untimely rainfall and against low temperatures. Both schemes are being tried on an experimental basis for 2 years. With the existing meteorological organisation it is only possible to predict conditions generally over the major meteorological sub-divisions of India, and in the experimental stage the warnings are being issued with reference to groups of two or more districts which form a homogeneous meteorological unit. Reports received from the officers on the warning list indicate that the messages were timely and generally useful, but that difficulties were experienced in disseminating the information quickly to the agriculturists. Full advantage

of such a service can be obtained only when there are receivers in each village and the messages can be transmitted to them by wireless.

During the year under review, the Meteorological Office, Calcutta, issued over 7,000 inland warning messages including special weather bulletins for rivercraft, warnings of probability of thundersqualls in Bengal and great danger warnings. The Meteorological Office, Poona, issued 1,975 inland warnings including those for low temperature and occasional special messages, while the Karachi office issued 156 warnings. The number of heavy rainfall telegrams sent direct to various officers by local meteorological observers was over 800. Reports on the working of the inland warning system were received from 31 officers on the Poona warning list and 120 officers on the Calcutta warning list and almost all of them expressed general satisfaction with the warnings issued. A few extracts from the Collectors' reports are given below :—

The Collector of Kolaba wrote on the 28th December 1936—

> ". . . . . In the case of heavy rainfall warnings of 24th and 25th June 1936, the Mamlatdar, Mahad, reports that the people of Mahad town had much appreciated the warning in advance; there were heavy rains on the 25th and 26th and the flood water had entered the town but as the people had received the intimation in time, they took necessary precautions to protect their property from being damaged by the floods".

The Collector of Surat wrote on the 24th December 1936—

> ". . . . . The warnings have served a useful purpose in enabling the cultivators to take precautionary measures against damage to their crops".

The Collector of Kanara wrote on the 7th February 1937—

> ". . . . . The telegrams really served a useful purpose. The warnings in June were useful in holding off sowings of paddy in wet fields. The cultivators, however, are not yet accustomed to these forecasts in order to control their operations".

Some of the officers have indicated the necessity of these warnings reaching them longer ahead than has hitherto been possible, and it is expected that the preparation of the afternoon chart at Poona which has been sanctioned with effect from 1st April 1937, will improve the situation in this respect in future. With more facilities for the dissemination of the warning messages and the education of the agricultural population in the use of the reports, better results may be expected in the matter of preventing damage to crops and other property.

The opinion given by the Sub-Manager, Burdwan Raj, Kujang, on the warnings received from Calcutta may also be quoted :—

> "The warning telegrams during the year 1936 were very accurate and satisfactory. Special mention must be made of the warning regarding the severe cyclone that passed over this area in the night of the 3rd October. Warnings regarding successive changes in the directions of the wind during this cyclone were very precise".

A few officers had minor criticisms to offer about individual forecasts of heavy rain not being received in time, or not proving correct. These received special examination to see how far the lessons to be learnt from them could be of use in future work.

V.—GENERAL.

A conference was held at Delhi in December 1936, at the instance of the Royal Air Force, to consider what additional meteorological facilities were necessary for safety in flying, both civil and military. Amongst the recommendations of the conference were (i) that a forecasting office be opened at Delhi, (ii) a few more current weather observatories be provided along the air routes, (iii) new observatories be started at Loralai, Dera Ghazi Khan (or Fort Munro) and the British Consulates at Jallalabad and Kandahar, (iv) the status of the observatories at Badin, Sukkur, Kalat and Sibi be raised from third to second class, (v) two posts of Meteorological Assistants be sanctioned for the meteorological offices at Peshawar and Quetta and (vi) an aviation section be opened and a second daily weather chart be prepared in the Headquarters Office at Poona.

In a Memorandum submitted for consideration by this conference, the possibility of obtaining these facilities without considerable fresh expenditure was indicated. One possible avenue of finding funds would be the saving of telegraphic expenditure which would result when each of the aeronautical wireless stations at Karachi, Delhi, Calcuttta and Rangoon begins to broadcast synoptic data relating to the surrounding region, reducing thereby the number of landline telegrams from that region to the other forecasting centres. The starting of a shortwave W/T station at Poona would lead to further savings in this direction. Another possible mode which it is desired to explore is the re-organisation of the department in a way which would not only work for economy but for increased efficiency; this contemplates amalgamation of activities and redistribution of work.

The possibility of providing more frequent forecasts from Poona was another matter which was discussed during the year. It is well known that 4 to 6 charts are prepared each day at forecasting centres in many other countries; but these systems are expensive and financial considerations had limited Poona's charts to one a day. Nowhere else in

the world has a forecasting centre to forecast for aviation with only one chart per day. In order to remedy this serious deficiency in the organisation without extra cost, ways and means of obtaining savings were explored. Experiments were made on the feasibility of using a 7-group weather code, in place of the 10-group code so far used. It was decided to introduce these shorter codes and use the resulting savings to prepare the afternoon chart at Poona. The savings, it was found, would not only provide this item but also another most desirable item, *viz.*, a shortwave W/T station at Poona. The location of a shortwave station at the Meteorological Office will bring the Headquarters into the national and international schemes of meteorological broadcasts. The W/T station will also be useful for dissemination of weather reports to aircraft flying over south India. The Government of India have sanctioned the proposals for the second chart at Poona with effect from 1st April 1937, as an experimental measure.

The International Meteorological Conference held at Warsaw in 1935 passed more than a hundred resolutions, and these had to be examined in detail. The changes in specification of the codes, as recommended by the Conference, were adopted in full and so also was the new form of International Ships' Code for the tropics. Of the many other recommendations of the Conference, some have been adopted and some are still under consideration. The need for exchange of weather reports with neighbouring countries continued to be felt, and fortunately it was possible towards the end of the year to arrive at decisions to begin, during the coming year, regular broadcasts of meteorological data from the shortwave aeronautical W/T stations at Rangoon, Calcutta and Karachi. The starting of the shortwave station at Poona and of broadcasts from Delhi, when a meteorological office is started there, will give a very good and useful network of broadcasting stations. It is hoped that these broadcasts will be heard by neighbouring countries and some of the meteorological broadcasts from neighbouring countries will be received in India.

The International Meteorological Conference at Warsaw agreed to the formation of two regional commissions,—one for Africa and one for the Far East, in order to enable the services in each group which have problems of common interest to meet periodically to discuss such problems and formulate recommendations to the parent body (*i.e.*, the International Meteorological Organisation) concerning their special problems. India is a constituent of the Regional Commission for the Far East. A meeting of this Commission was held at Hong Kong in January 1937 and Mr. S. Basu was deputed to attend the Conference. A number of questions of common interest, like hours of observation, codes, exchange of regional broadcasts, etc., were discussed at the Conference, and the resolutions are now under the consideration of the International Meteorological Organisation.

In recent years, India has had the unenviable distinction of being visited by series of disastrous earthquakes which have naturally focussed attention to the urgent need of instituting a branch of public service, which would devote its attention exclusively to the problem of seismological investigation. Three departments—the Geological, the Meteorological and the Geodetic—study different aspects of the subject but in none of these is it studied continuously; and the smaller earthquake shocks receive little or no attention. In view of the importance of investigating on proper lines the seismological problems of India, a conference was convened in January 1936, at which the Surveyor General, the Director of the Geological Survey of India and the Director-General of Observatories went into the question of forming a seismological organisation in India. The conference recommended the formation of a Seismological Branch in India under the technical control of a Seismological Committee, consisting of the Surveyor General (or Director, Geodetic Branch), the Director, Geological Survey of India and the Director-General of Observatories and for the present, under the administrative control of the Director-General of Observatories. The proposals were under the consideration of Government during the year under review, and it is hoped that it will be possible to make a start with the Branch soon.

The Government of Burma decided to start an independent Meteorological Service on separation of Burma from India. The scheme which was drafted at Poona involved the revival of the meteorological office at Rangoon. At the request of Burma, the Government of India agreed to send Dr. S. C. Roy, one of the Senior Meteorologists of this department, on deputation for a period of five years, as the Director of the new Meteorological Service in Burma, and also two trained Assistant Meteorologists as Assistant Directors. Steps were also taken to fill up the existing posts of meteorological assistants and observers in Burma by men who volunteered for service in that country. Meteorological work in Burma was completely taken over by the new service with effect from 1st July 1937, except in regard to storm warning which will continue to be done by India Meteorological Department for some time.

The Government of India decided during the year that, in addition to the All-India Weather Summary telegram, four Regional Weather Summary telegrams giving important weather features over Peninsular India, northern and central India, northwestern India, and northeast India and Burma should be issued daily by the Meteorological Department. They also decided that the All-India Weather Summary telegram should be supplied only to *bona fide* press subscribers, and to such non-press subscribers of all the four regional telegrams as may elect to have it in lieu of the regional telegrams and that other non-press subscribers should be supplied with regional summaries only.

The department rendered assistance to the Mount Everest Expedition of 1936 by providing special weather reports and forecasts to the Party through their radio station at Darjeeling. Weather reports were

also furnished to the base camp at Skardu of the French Karakorum Expedition. Arrangements were made for the provision of necessary meteorological facilities in connection with the Paris-Saigon-Paris Air Race. Assistance was given to Prof. Victor Neher of the Californian Institute of Technology for making cosmic ray and allied measurements at Madras and Kodaikanal. Air samples from Poona and other places were collected and sent to Prof. F. A. Paneth of the Imperial College of Science and Technology, London, in connection with a world survey of helium content. Assistance was, as in the past years, given to Dr. K. C. Mehta of the Agra College for his researches on cereal rusts.

The death, on March 12, 1936, of Dr. N. A. F. Moos removed from the field of terrestrial magnetism one of its well-known representatives. His scientific activities were intimately associated with the development of magnetic work of the Bombay Observatory of which he was Director from 1896 to 1919. Dr. Moos published a number of valuable discussions on magnetic variations. His most important contribution was, however, his work in two volumes on "Colaba Magnetic Data, 1846-1905". In his address as President of the General Assembly of the International Association of Terrestrial Magnetism and Atmospheric Electricity, Dr. J. A. Fleming, Director, Department of Terrestrial Magnetism, Carnegie Institution of Washington, referred to Dr. Moos's work in the following words :—

> "* * * his work in two volumes 'Colaba Magnetic Data, 1846-1905' presented and discussed in great detail this remarkable series of observations extending over 60 years and represents a prodigious amount of labour, forming an outstanding contribution to the science of terrestrial magnetism and a store-house of information for its students."

VI.—OFFICES AND OBSERVATORIES.

A list of the staff of the India Meteorological Department as it stood on the last day of the year under review is given in Appendix A.

Headquarters Office, Poona.—Dr. S. K. Banerji officiated as Director-General of Observatories during the absence on leave of Dr. C. W. B. Normand from 14th August 1936. to 11th February 1937.

The principal items of scientific work done in this office have been briefly mentioned under Chief Features. Twenty-three meetings of the colloquium were held during the year under report. As in previous years the meetings were generally devoted to discussions which were opened by a member of the staff, or one of the research students, or some outside scientific worker who took as his special subject either his own original work or a recent important paper published in extra-departmental scientific journals. Among the distinguished scientists

who addressed the colloquium during the year may be mentioned Sir John Russell, F.R.S. of the Rothamstead Experimental Station, Lt.-Col. E. Gold of the London Meteorological Office, Dr. S. Chandra Sekhar of the Chicago University and Professor K. S. Krishnan of the Indian Association for the Cultivation of Science, Calcutta.

The 24th session of the Indian Science Congress was held at Hyderabad. As a measure of economy, only two officers were deputed to attend the meeting on duty. Dr. C. W. B. Normand, Director-General of Observatories, has been elected to preside over the Section of Physics and Mathematics at the forthcoming Jubilee Session of the Science Congress in Calcutta to which eminent British and other foreign scientists have been invited.

The Government of India nominated Dr. S. K. Banerji to represent India on the new Commission of Aeronautical Meteorology of the International Meteorological Organisation. This new Commission will consider meteorological problems relating to aviation and aim to co-ordinate supply of meteorological information to airmen in different countries.

The activities of the different sections of the Headquarters Office are briefly described below :—

(*a*) *General Section.*—This section deals with matters relating to the administration of Headquarters and Sub-Offices including such items as budget, accounts, establishment, general registry, technical questions relating to aviation and matters involving fresh expenditure, as well as arrangements for the co-ordination of technical work.

Much work was involved in giving effect to Government sanctions in connection with the Empire Air Route Development Scheme. The introduction of night balloon and current weather work at the different stations involved considerable consultation and correspondence with the Aviation and Wireless Departments and with the sub-offices. Instructions regarding visibility and cloud observations at night were drawn up and arrangements for training the observers in these observations were made. Suitable sites were selected at the several aerodromes for installation of searchlights. Some schemes of further development in meteorological services to aviation were considered. These concerned special requirements of the seaplanes, the improvement of the organisation west of Karachi, etc. Plans of the Meteorological buildings to be built on the aerodromes in connection with the Capital Expenditure Programme were scrutinised and necessary action taken. New editions of the pamphlets on "Meteorological Organisation for Airmen" and of the Pocket Card of Aviation Weather Codes were prepared. The specifications of elements included in codes for aviation reports had to be modified in order to fit in with the new international resolutions, and the airmen notified regarding the changes. A scheme of broadcasting

synoptic data of selected stations from the aeronautical wireless stations in India and Burma was worked out.

In connection with a conference held at Delhi, a memorandum was prepared in which the question of re-organisation of the Meteorological Department, with a view to achieve the desired improvements without considerable fresh expenditure, was considered. Another subject to which considerable attention was given was the scheme for the preparation of a second daily weather chart and the institution of a shortwave wireless station at Poona without exceeding the present budget provision of the department. Consideration of the resolutions of the Warsaw International Meteorological Conference, 1935, and of the Regional Meteorological Conference held at Hong Kong early in 1937, scrutiny of agenda and examination of points to be placed before meetings of other international bodies like the Commissions of the International Meteorological Organisation and the International Commission for Air Navigation resulted in considerable work for the section. On the purely administrative side, the separation of Burma entailed heavy work. A scheme was worked out for an independent meteorological service in Burma on separation and submitted to Government. Preparation of separate budgets for the India and Burma Meteorological Services, transfers of staff and other necessary adjustments on separation, the discussion of the transitory arrangements as well as terms of future co-operation and division of work between the two services, preliminary assistance to the new service to start its work including the making of necessary arrangements with other departments, were some of the major items of work that were attended to in this connection. These items naturally involved a large increase of correspondence work. The introduction of provincial autonomy in India and the resulting position, in the light of the new Government of India Act, of buildings and lands on which meteorological observatories stand was another matter which had to be examined.

At the suggestion of this department, the Government of India, in consultation with the Auditor General, arranged a system of annual local audit for the Headquarters and sub-offices of this department.

Weather Section.—This section is responsible for the issue of warnings to shipping and ports in the Arabian Sea, of weather reports to aircraft in the Peninsula, of daily weather telegrams which appear regularly in the newspapers and of the Daily, Weekly, and Monthly Weather Reports and for the preparation of portions of the Annual Summary for the India Weather Review. It also issues warnings to individual interests in respect of heavy rainfall and low temperatures for the whole country excepting northeast India, Burma and Sind. Details regarding the marine, aviation and inland weather warnings issued by this section are incorporated in the relevant foregoing sections of this report.

From the 1st August 1936, instead of issuing only one Daily Weather Telegram covering the whole of India and Burma, the Weather Section of the Poona Office began to issue one All-India Daily Weather Telegraphic Summary to the Press, and one daily regional telegraphic summary covering the Peninsula and another covering the United Provinces, Central India and the Central Provinces to non-Press subscribers.

Action on international resolutions passed at the Warsaw Conference engaged considerable attention of the Section. Arrangements were made to replace N_L (the amount of low cloud) by N_h (the amount of cloud whose height is reported) in the Daily Weather Message Code and to adopt international amendments to the specifications of past and present weather remarks (W and ww). Also, necessary action was taken to adopt geodynamic in place of geometric levels for reduction of atmospheric pressure data.

With a view to reduce telegraphic expenditure, experiments were made upon the feasibility of using a 7-group code for reporting surface observations. A 7-group code based on the new international code was evolved and it was decided to introduce it in the department, the chief feature of the new code being that there are no special check figures as there were in the older code.

Government sanctioned the routine preparation of an afternoon chart at Poona with effect from 1st April 1937, and this greatly increased the forecasting facilities of the section.

The important additions to the inland warning work of the section which took place during the year have been referred to in a previous section of this report.

At the request of British Liaison Officer to the French Expedition to the Karakorum Mountains, special forecasts of weather over Kashmir were sent to the base camp at Skardu, indicating the advance of the monsoon and its progress over that area. From the 24th February 1937, arrangements were made for the reception at the Calcutta Radio and transmission to Calcutta and Poona meteorological offices of 0200 G. M. T. Bangkok broadcasts containing Siamese observations.

Two candidates for Pilots' "B" licence were trained and examined in elementary meteorology.

Observatories Section.—This section continued to administer and arrange for the inspection of departmental observatories in Central and South India. Fifty-five observatories in this area were inspected during the year. Taking the department as a whole, 4 second class observatories, 2 third class observatories and 1 fourth class observatory were started during the year and 4 non-departmental observatories closed down. The observatory at Nasik was instructed to telegraph temperature observations to Poona between December and February

in connection with issue of cold wave warnings for the Nasik area. In connection with the issue of forecasts to the Mount Everest Expedition 1936, certain observatories were asked to send additional weather telegrams to Calcutta.

Instruments Section.—The section continued to be responsible for the purchase, test and repair of meteorological instruments and the issue of these instruments as well as forms and stationery to the departmental surface observatories. During the period under review, 1,150 instruments were purchased, 761 were recalled from observatories and replaced, 1,131 new instruments were issued to departmental observatories, and 22 were loaned. 1,121 instruments were tested, and 602 repaired or reconditioned. 2,409 items of stores and instruments were issued to officers and sections at Headquarters. Kew Pattern Barometers (station type) were introduced at 28 stations.

In connection with the introduction of night flying on the Empire Air routes, the standardisation and purchase of the equipment for determination of visibility and cloud height at night, and the installation of the instruments at the various stations involved much work and correspondence on the part of the section. For measuring heights of low cloud at night, different types of searchlights and alidades were tried, and ultimately the London M. O. type searchlights with 16″ projector and simple clinometer were adopted for departmental use. Suitable stands for the alidade and housing for the searchlights were made in the Poona workshop and specifications and instructions with blue prints for laying the electric lines in connection with their installations were prepared. Installation of searchlights was completed at Jodhpur, Karachi, Poona, Agra and Calcutta, and action is in progress for the installations at Allahabad, Gaya, New Delhi and Jacobabad. A few self-recording theodolites were obtained in order to facilitate observations of pilot balloons at night. Electrical anemometers designed for quick supply of current weather reports to pilots by indication of visible signals in the observer's room were made in Poona workshop, and action started for their installation at various stations. Arrangements were made for purchase of Bennett Casella Visibility meters and ordinary Municipal Street lamp type lanterns for night visibility observations. Suitable arrows and cylinders were designed for exhibiting upper winds on the pilot's Notice Board at Drigh Road. Panels and cross pieces for exhibition of current weather were also obtained.

As recommended by the Polar Year Commission (Copenhagen meeting in May 1933), arrangements were made to overhaul one of the magnetometers of the Alibag Observatory and to standardise its magnets at Abinger (Greenwich).

At the instance of the Director, London Meteorological Office, two Stevenson screens of the newly designed smaller London M. O. type were got made at Agra and arrangements were made to take comparative observations at Poona and Agra of temperatures within these and

the standard I. M. D. type Stevenson screens. At the request of the Director of Civil Aviation, special arrangements were made to test the "combined accelerometer and air speed recorder" which was loaned by the Director of Civil Aviation to Messrs. Tata Sons, Ltd.; Messrs. Tata Sons, Ltd., were suitably advised regarding the installation and working of the instrument on one of their machines.

Considerable progress was made towards the setting up of the Poona Museum.

1,225 visitors on 114 occasions were shown round the office at Poona. Technical advice for the erection of Dines' P. T. anemograph was given to the Baroda and Jaipur States and the City Broad, Mussoorie.

Marine Section.—The duties of the section, *viz.*, the co-ordination of the work of collection, examination, and study of ships' weather logs were carried on as usual.

Arrangements were made for the adoption by ships in the Indian waters of the new tropical form of the international weather code for ships and of the new hours of observations as internationally approved. A revised edition of the departmental publication entitled "Weather Codes for Ships in the Indian Waters" became, therefore, necessary and was prepared during the year. A Marine Code Card was also prepared. The form used by ships for recording observations and preparing radio weather messages was revised so as to be in line with the new Ships' Code. The departmental publication entitled "Code of Storm Warning Signals at Indian Ports" was re-written in two separate pamphlets with the titles "The Code for Storm Warning Signals at Indian Maritime Ports" and "The Code for Storm Warning to Ganges Delta Ports and River and Police Stations". Two meetings of ships' captains were arranged at Bombay and attended by the officer in charge of the section in order to explain to the captains the new Ships' Code and other allied matters.

At the request of the London Meteorological Office, the meteorological portions of the "West Coast of India Pilot, 1926" relating to Indian territories were checked and revised. The scheme of broadcasting, for ships' use, synoptic data of selected stations from the wireless stations at Bombay, Calcutta and Matara was improved by adding in the broadcasts synoptic data of ships in selected positions in the Indian waters and noting invariably to add the data of two inland stations. This enabled the ships to draw isobars on their charts with some degree of reliability.

Arrangements were made with the Wireless Department for the reception of 3 hrs. G. M. T. observations from British Selected ships when in the Arabian Sea. Comparative readings of thermometers in leeward insolated and windward shaded Stevenson screens and of the

Assmann Psychrometer on H. M. I. S. Investigator for the last survey season were scrutinised. The difference between the amounts of rainfall recorded in the two raingauges on board this ship during the last survey season was worked out and inferences drawn. Essays in Meteorology by cadets of the I. M. M. T. S. Dufferin were judged, and the usual prize of an aneroid was sent to the Captain Superintendent, Dufferin, for presenting to the cadet who stood first in Meteorology.

The Surveyor-in-charge, Marine Survey of India, requested that the synoptic messages which are at present being sent to Matara may be sent to the Navy wireless station, Bombay Fort, for broadcasting, Matara picking and re-broadcasting the data if necessary. His Excellency the Naval Commander-in-Chief, East Indies Station, Colombo, concurred in the proposal. The question was under further examination.

Data for the proposed Climatological Atlas of Indian Seas were received from the Meteorological Office, London, and the drawing of the charts was taken in hand. Most of the Polar Year data were put in the form recommended for publication.

Upper Air Section.—Sounding balloon work was continued but was rather restricted, 26 instruments being let off from Poona and 22 from Madras. 31 of these were recovered. Observations of upper air temperatures and humidities continued to be made from aeroplanes by the Royal Air Force at Peshawar and Karachi; occasionally such observations were also made at Fort Sandeman. The data of the first two stations are being received at Poona by telegram and after suitable reduction are being published in the Indian Daily Weather Report.

Considerable progress was made in bringing the publication of Upper Air Data up-to-date. Pilot balloon and other data of Region D. (according to the classification of the International Aerological Commission) for the period September 1933 to December 1934, were forwarded to the Secretary of the Commission.

Observations of 23 pilot balloon ascents from H. M. ships in Indian waters were received by post and the results worked out in a form suitable for comparison with inland data. Tables of wind frequencies up to 3 kms: published in Scientific Note No. 17 were revised and arranged for publication as a Scientific Note. A paper on the detailed distribution of rainfall in south India associated with storms was completed. An officer from the section was sent on tour to Madras to assist Dr. Neher of the Californian Institute of Technology in letting off balloons with cosmic ray recording apparatus.

Statistical Section and Library.—The duties of this section include statistical work connected with the issue of the seasonal forecasts and with climatology; the care of the library, the editing and distribution of departmental publications and the supply of general meteorological

information in reply to enquiries are also included in the work of this section.

Statistical work to improve the existing forecasting formulæ was continued as in previous years. The improvement consisted mainly in a new way of combining the known factors already found to be reliable. The new formulæ worked out in this manner have yet to be tested for reliability.

1 Memoir and 3 Scientific Notes were sent to press during the period under report, 5 other research papers were received and were being considered for publication. The "Catalogue of Periodicals in the Libraries of the Department", sent to press last year, was issued. The brochure "Meteorology for Airmen in India", also prepared last year, was published and distributed.

368 requests for climatological, meteorological and, occasionally, astronomical information were received and replied to.

The routine activities of the Climatological Branch, consisting mainly of scrutiny of the accuracy of records of surface observatories, preparation of meteorological tables for the routine publications of the department and supply of periodical meteorological reports and data to various government and public officers, were carried on as in previous years. The usual advisory functions of the Director-General of Observatories with regard to the registration of rainfall, inspection of raingauges and the publication of the provincial tables were also carried out.

In accordance with the resolution No. 74(*b*) of the Conference of Directors at Warsaw in 1935, relating to intercontinental exchange of climatological data, arrangements were made for the broadcasting from Cairo of monthly mean values of meteorological elements of 16 stations in India and Iran from January 1937.

Two long range forecasts were issued in August; in one case the rainfall was in considerable excess of the predicted minimum and in the other just below the predicted minimum. The indications in June for the monsoon rainfall and those in January for the winter precipitation were not sufficiently decisive; hence the corresponding forecasts were not issued.

Agricultural Meteorology Section.—The work on the "experimental or biological" aspects of agricultural meteorology and extension of co-operation to Agricultural institutions and workers in India continued to form the major items in the programme of the section. The officers in charge of the research schemes inaugurated by the Imperial Council of Agricultural Research were given advice on the meteorological aspects of their work. A number of agricultural assistants who came to Poona on deputation were given special training in agricultural meteorology. Other agricultural workers were helped by the issue of

instructions regarding the installation and upkeep of meteorological instruments, and by the calibration of their instruments that were sent to Poona. The number of instruments received for test from agricultural departments was 150.

The problems connected with frost and its prevention continued to engage the attention of the section. The scheme for the issue of cold wave warnings to provinces liable to frost in north and central India and another scheme drawn up by the section for issuing warnings for heavy or untimely rainfall to each of the districts of the Bombay Presidency were given effect to on an experimental basis by the forecasting section (Weather Section) at Poona.

At the Central Agricultural Meteorological Observatory, the series of experiments intended to provide a measure of the different ways in which solar energy and rainfall are disposed of at the earth's surface were continued. Progress was made with the study of the climates of different crops and with the analysis of the data collected. An investigation on soil temperatures and their dependence on the nature of the soil layers was commenced. Investigations on (1) the exchange of heat energy by radiation between the soil and the atmosphere, and between the different air layers themselves, (2) the influence of water vapour in the atmosphere on these radiation processes, and (3) the radiation equilibrium of an object near the ground in relation to the zenith distance of the portion of sky concerned, etc., were carried out, and the results obtained were of great use in understanding the phenomenon of nocturnal cooling. Another subject in which further progress was made is the exchange of moisture between the soil and the air layers near the surface. Some of the Indian soils, *e.g.*, the black cotton soils, are found to be so hygroscopic that, when dried completely, they can be used as efficient desiccating agents. The direct estimation of soil moisture at different depths at weekly intervals was continued.

As a result of experience gained in the section, it has been found that the simple "Piche" evaporimeter exposed in the Stevenson screen would provide useful estimates of evaporation. About 36 Piche evaporimeters have been standardized by the section and will soon be installed at a net-work of selected stations in India. This scheme, when completed, may be expected to yield new information regarding this important climatic factor.

On the statistical side, a number of investigations were completed, and others were in progress. A series of papers on weather in relation to the cotton crop in the Bombay Presidency were published by the Imperial Council of Agricultural Research, as supplements to the annual report of the section for the year ending August 1935. Investigations on the frequency of hail storms in India, frequency of heat waves and cold waves, and of floods and droughts in India were in progress.

After reviewing the first three years' work of the Agricultural Meteorology Section, the Advisory Board of the Imperial Council of Agricultural Research passed a resolution in February 1936, to the effect that it "should be made a permanent activity of the India Meteorological Department under the Director-General of Observatories at Poona". The Governing Body of the Council confirmed the above resolution at its meeting held in September 1936, and decided that, in the event of the Government of India making the Section permanent, the Imperial Council of Agricultural Research would make a contribution not exceeding Rs. 12,000 per annum for a period of five years towards the cost of establishment and contingencies, the entire cost being met by Government thereafter. Detailed proposals for giving effect to the above resolution were submitted to the Government of India during the year under review. Meanwhile, the tenure of the section has been extended till the end of March 1938.

Sir John Russell, F.R.S., who came to India to review the work done by the research schemes inaugurated by the Imperial Council of Agricultural Research visited the Agricultural Meteorology Section at Poona and saw its work in detail on the 7th December, 1936. He also visited the Central Agricultural Meteorological Observatory.

A list of papers published by the staff and students of the section is included in Appendix B.

Upper Air Observatory, Agra.—This observatory administers all the pilot balloon stations of the department except those at other departmental centres. Two new pilot balloon observatories, one at Trichinopoly and the other at New Delhi, sanctioned in connection with the Empire Air Route Development Scheme, were opened during the year bringing the total number of pilot balloon observatories to 38. The long-contemplated shift of the Patna Pilot Balloon Observatory to Gaya was effected on the completion of the necessary buildings on the Gaya aerodrome in March 1937. In connection with the Mount Everest Expedition, two pilot balloon stations were opened temporarily for about two months at Purnea and Motihari, and the pilot balloon observatory at Dacca was shifted to Darjeeling for the same period. Arrangements were also made to report morning and afternoon pilot balloon data up to 9 kms. above sea level from Agra, Allahabad, Chittagong, Lahore, Sambalpur and Tezpur for use of the Expedition.

The work of equipping pilot balloon stations on the air routes for night flying demanded considerable attention of the Agra Office. Eight pilot balloon Stations on the air routes were provided with the necessary equipment and trained staff for letting off and observing balloons at night. Hours of the daily pilot balloon flights at these stations were revised in order to fit in with the night flight.

The duties of the first class observatory and seismological observatory at Agra and the preparation of manuscripts of monthly means of upper winds, seismic data, sounding balloon data, daily pilot balloon

data, etc., for routine publications of the department were carried on as usual.

90 sounding balloon ascents were made at Agra. 45 instruments were retrieved, out of which 17 belonged to the lot let off during the previous year. Construction of a new type of calibration apparatus for calibrating a dozen Dines type meteorographs at a time was taken in hand. The construction of a calibration chamber for aeroplane meteorographs was also taken in hand. A searchlight was installed at Agra for measuring the height of low clouds. Four searchlight boxes were designed, made and supplied with instructions for their installation. Experiments were made to improve the records of the Milne-Shaw seismographs and also in connection with certain damping arrangements for the Omori-Ewing seismographs. New attachments were designed for preventing the coupler of the Milne-Shaw and the stylus of the Ewing-Omori seismographs from getting dislodged during great shocks. These attachments were distributed to the different seismological stations of the department. Radio-meteorographs received from Poona were tested, and preparations made for trial ascents. A few balloons were let off and followed by means of a marine theodolite from a boat on the Jumna in order to gain experience in the use of this theodolite. Two complete sets of final test equipment for sounding balloon meteorographs were made for use in connection with the study of post-monsoon storms in the Bay of Bengal, and additional observers were trained in the technique of letting off sounding balloon meteorographs. A Kolhorster Cosmic Ray apparatus was installed, and measurements of cosmic ray intensity were commenced at Agra. Measurements were made with a Holophane Lumeter of the horizontal transmission co-efficient of the atmosphere. Further improvements were made in the theodolites and other equipment for night balloon ascents. Experiments were made with new varieties of rubber sheetings and balloons in order to test their suitability for upper air work. Designs were made of a distant reading anemometer and a distant reading windvane.

Experiments were made to investigate the cause of balloon explosions like the one which occurred at Purnea in 1933 and these indicated that the explosions were due to electric sparks generated on bursting.

The Survey of India constructed a Latitude Observatory in the compound of Upper Air Observatory, Agra, and started observational work.

Five pilot balloon observatories were inspected during the year. Five candidates for Pilot's 'B' licence were trained and examined in elementary meteorology.

A Handbook of Pilot Balloon Observatories was completed, and a preliminary draft of a Handbook of Technical Instructions for upper air-

observatories prepared. Administrative instructions to pilot balloon observatories were revised.

The impending separation of Burma gave rise to considerable work in the matter of transfers and other adjustments of staff. Questions regarding the supply of hydrogen, instruments, etc., to the pilot balloon stations in Burma after separation had also to be considered.

304,032 c. ft. of hydrogen was manufactured during the year under report. A scheme for purchasing hydrogen from a commercial firm was under consideration.

Colaba and Alibag Observatories.—These observatories which form the departmental centre for geophysical studies carried on, as usual, the routine meteorological, seismological, magnetic and atmospheric electricity work. The Colaba Observatory also received regular rhythmic time signals from Bordeaux or Rugby for rating the standard clocks and maintained the time supply service for the Port of Bombay. The time ball at the Prince's Dock tower was dropped regularly at 8-30 A.M. I. S. T. The Colaba Observatory also continued to stock the Royal Indian Navy chronometers and watches for maintenance and rating, the average number of instruments for daily rating being 78.

The work of scrutinising and collating seismological observations made at the departmental seismic stations was continued. A few photostat copies of Colaba seismograms were sent on request to foreign seismological and geophysical institutes.

At the Alibag Magnetic Observatory, continuous records of the various magnetic elements were obtained, and the observations of the absolute values of these elements were made as usual. Data regarding the magnetic character of days and the daily range of variations of magnetic elements were supplied regularly to the Royal Meteorological Institute, De Bilt, and the Solar Physics Observatory, Kodaikanal. In accordance with the recommendations of the International Commission for Terrestrial Magnetism, the days of the years 1895-1905, which had already been classified for their magnetic character according to local time, were reclassified taking them as Greenwich days, retaining the old grades of classification. The Colaba data thus reclassified were sent to the Chief Director, Royal Netherlands Meteorological Institute, De Bilt, Holland, at his request. A study was commenced of the day-to-day variability of the horizontal force of the earth's magnetic field at different places, taking the beginning of the day to commence from each of the hours 0 to 24.

Registration and measurements of the atmospheric potential gradient were carried on regularly at Colaba. Measurements of atmospheric electric conductivity were made on selected days. A study was commenced on the air-earth current from elevated points during times of thundery weather. A paper on atmospheric electric potential gradient, conductivity and air-earth current on electrically "quiet" days at Colaba was completed.

Regular registration and observation of meteorological elements by self-recording and eye reading instruments were carried on at Colaba and Alibag.

The gestetnered Daily Weather Report giving the summary of the principal features of weather over western India, based on the material telephoned from Poona Meteorological Office, was issued regularly during the period 1st May to 30th November.

The pilot balloon station sanctioned for Juhu remained located at the Colaba Observatory till the 17th January 1937, whereafter it was transferred to Juhu.

The collection of weather logs from ships calling at the Bombay Port, and the standardisation of their barometers were carried on as usual.

Copies of the Observatory Volume for 1934 were distributed, and the proofs of the Volume for 1935 returned duly corrected to the press. The work of compilation of the Polar Year data was completed and the final manuscripts were sent to the Headquarters. At the request of the Superintendent, Archæological Survey of India, Western Circle, observations of humidity were taken at the Elephanta Caves from 2nd to 5th December, 1936, and reports sent to the Elephanta Enquiry Committee.

A fire-proof photographic dark room and an adjoining store-room were constructed in place of the old photographic room destroyed by fire in March 1936. Chemical fire extinguishers were installed in the observatory premises at Colaba and Alibag.

19 meteor reports were supplied during the period to the Instructor in Gunnery, Royal Artillery, Colaba.

Alipore Observatory and Meteorological Office, Calcutta.—The principal functions of this office were (1) the issue of storm warnings for the Bay of Bengal, (2) heavy rainfall warnings for northeast India and the surrounding areas, (3) squall warnings for Bengal, (4) the issue of weather reports and forecasts for aviators flying in northeast India and Burma, including the regular air mail services on the air route between Allahabad and Victoria Point.

The Calcutta Daily Weather Report continued to be published throughout the year and had 65 subscribers at the end of the year. A daily weather report for Burma was also issued between June and November 1936 and delivered to the Associated Press of India for transmission to Rangoon. Issue of a daily telegraphic regional weather summary covering northeast India and Burma was commenced with effect from 1st August 1936. A daily weather bulletin briefly summarising the weather conditions at the head of the Bay and over deltaic Bengal was issued to the All-India Radio with effect from the 1st September 1936 for broadcasting through the Calcutta Station. This was for the special benefit of ocean and river craft. In the synoptic reports for ships, issued through Calcutta and Matara Radios, synoptic observations of a few ships in selected positions in the Bay of Bengal were added with effect from October 1936.

Weather reports and forecasts for the Everest region were issued by the Calcutta office to the 1936 Everest Expedition through the Party's Radio at Darjeeling twice daily from the 25th April 1936 to the 6th May 1936 and thrice daily from the 7th May 1936 to 15th June 1936. The following telegram was received on the 16th June from Mr. Hugh Ruttledge, Leader of the Expedition.

"Monsoon renders further operations impossible. Wireless closes down today and expedition leaves for home. Infinitely beholden to you for most valuable help throughout * * * ."

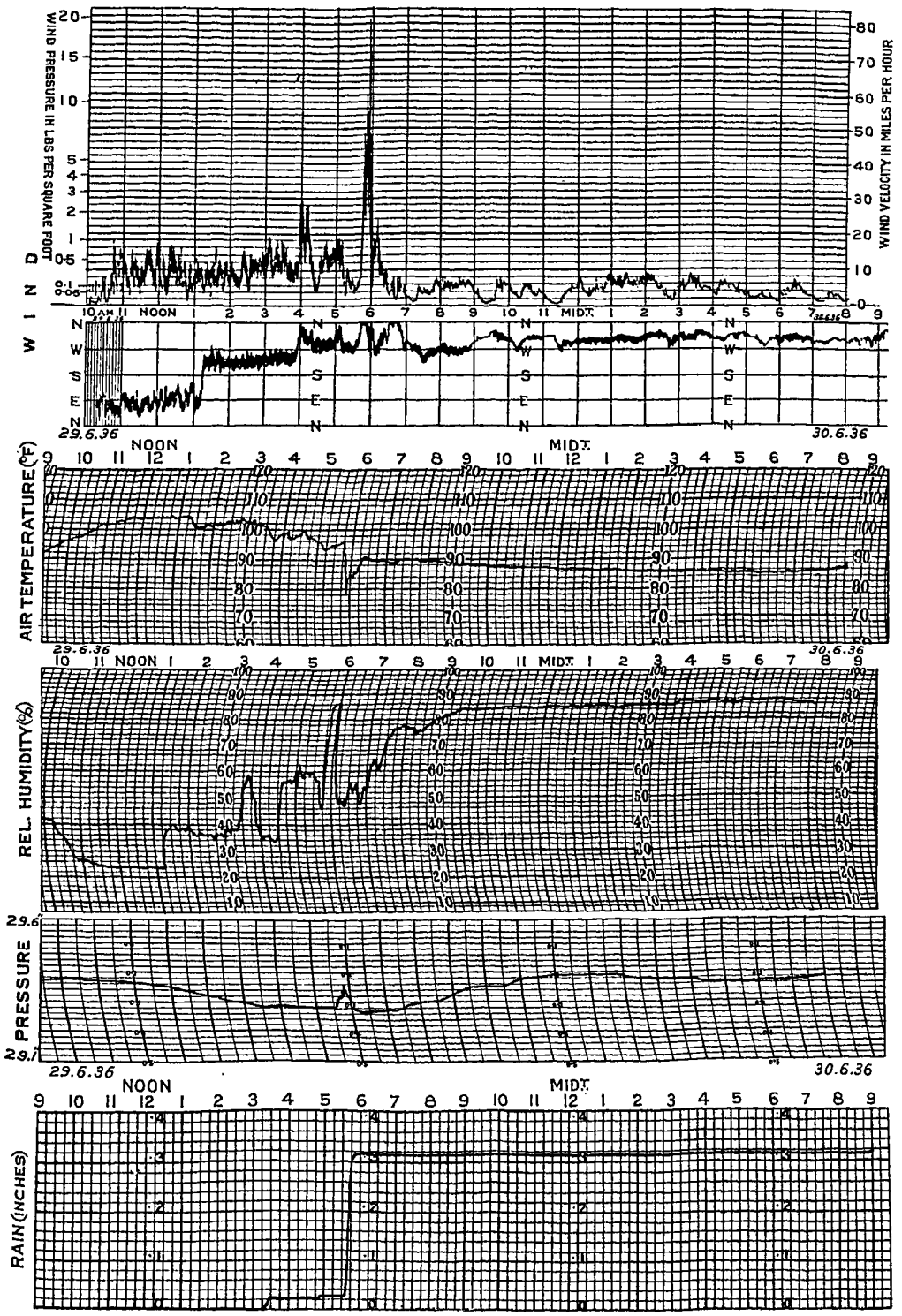
The Calcutta office was responsible for administration of 103 surface observatories, besides the Alipore observatory. The voluntary observatories at Pusa and at the University College of Science, Calcutta, were abolished during the year, while new departmental observatories were started at Shwegyin and Henzada. 38 departmental observatories were inspected during the period.

The meteorological and seismological observations as well as the time determination and time signalling work of the Alipore observatory were carried on as in the past years. The old practice of giving time signals to Fort William by Time Ball was given up, and arrangement was made for the transmission of the signals by telephone.

The work of testing the meteorological instruments of the Mathematical Instrument Office, Calcutta, of the Chemical Examiner to the Government of Bengal and of Ships' Captains was carried on as usual. Some training in meteorology was given to the senior men of the Port Commissioner's light vessels. The growing demand from the public for meteorological and other information was attended to. The office continued to collect and examine logs from ships in the Bay of Bengal. Arrangements were made for supplying meteorological and seismic information to the Sun Advertising Co., for display in their Electric Newspaper at the Esplanade, Calcutta.

Pilot balloon observations continued to be made at Alipore, pending construction of the necessary buildings at Dum Dum. Current weather reports and messages in Q code were supplied from Alipore and on certain days from Dum Dum. The Professional Assistant or some other member of staff was deputed to attend the Dum Dum aerodrome on air mail days in order to supply current weather reports from Dum Dum and meet pilots. Night balloon ascents were commenced at Alipore from the 13th July 1936. A searchlight was installed for the measurement of heights of base of low clouds.

The provision of additional meteorological facilities to regular air services within the administrative area of the Calcutta Office, such as the introduction of night balloon ascents at Calcutta, Allahabad and Gaya, maintenance of longer watch hours at Calcutta and Allahabad, establishment of new current weather stations at Asansol, Henzada, Tavoy and Gaya, supply of current weather reports from Dum Dum, establishment of closer contact between pilots and meteorological staff


WIND
WIND PRESSURE IN LBS PER SQUARE FOOT
WIND VELOCITY IN MILES PER HOUR
10 AM 11 NOON 1 2 3 4 5 6 7 8 9 10 11 MIDT. 1 2 3 4 5 6 7 8 9
N W S E N
29.6.36
30.6.36
AIR TEMPERATURE (°F)
REL. HUMIDITY (%)
PRESSURE
RAIN (INCHES)

RECORDS OF A SEVERE THUNDERSQUALL OVER DRIGH ROAD (KARACHI) AT ABOUT 6 p. m. ON 29-6-1936.

During the thundersquall, the wind reached a velocity of 81 m. p. h.; a very marked fall of temperature occurred and there was a sharp rise of relative humidity and pressure. 30 cents of rain fell in about 15 minutes. Buildings at the R. A. F. Aircraft Depot, Drigh Road suffered considerable damage.

at Dum Dum and the auxiliary centres under Calcutta demanded considerable attention during the year.

Arrangements were made for receiving the Siamese broadcasts as a regular measure from 24th February 1937.

The Meteorological Office, Karachi.—This office continued to supply weather reports and forecasts for the main air route from Bahrein to Allahabad, for the feeder route, Karachi to Lahore, and for the Karachi-Ahmedabad portion of Karachi-Madras route. This office also supplied route forecasts to aircraft flying over other routes in its area of responsibility. Arrangements for improving the service particularly in connection with night flying engaged considerable attention during the year. In connection with the Paris-Saigon air race, arrangements were made for supply of weather reports and forecasts for the use of the participants, and for broadcasting weather data of selected stations on the route from the Karachi W/T for several days.

The supply of certain observational data to the R. A. F. Meteorological Officers at Peshawar and Hinaidi was continued. The evening synoptics were also sent to the Meteorological Officer, Heliopolis. Special weather reports and forecasts were supplied to 12 special flights of the R. A. F. planes and flying boat squadrons. The total number of weather reports and forecasts issued to the R. A. F. numbered 288. Besides these, 4,406 sets of routine weather data were supplied to the R. A. F. The number of observations received from the R. A. F. personnel numbered 1,443. The Aircraft Depot, R. A. F., Drigh Road, made 35 aeroplane ascents for meteorological observations.

The Karachi Daily Weather Report continued to be issued during the year, the number of subscribers being 31 at the end of the year. A daily telegraphic regional weather summary for northwest India was issued from this office with effect from the 1st August 1936. This office continued to co-operate with the Locust Research Entomologist by supplying him with meteorological data, by scrutinising the observations taken by him and in other ways. In connection with the Everest Expedition, technical telegrams were issued from this office to the Calcutta office whenever necessary.

Pilots of the airways frequently visited the office to see the charts and to discuss weather situations personally with the officers. Weather logs were received from the pilots of the Indian Trans-Continental Airways, Indian National Airways and the Tata Sons, Ltd.

Nine candidates for pilot's B Licence were trained in elementary meteorology, and two were examined.

The total number of observatories under the administrative control of Karachi office was 85 at the end of the year; of these 41 were inspected during the year. The observatories at Bahawalpur and Sri Ganganagar were raised to 2nd class, and a new 2nd class observatory was started at Fort Abbas.

The Karachi Weather Message Code, 1931, was replaced by a new one on the line of the latest international code with effect from 1st January 1937 at observatories in Iran and the Persian Gulf. The Indian Code was introduced in south Baluchistan stations which were hitherto using a special code.

The observatory at Drigh Road continued its functions as a 1st class observatory and auxiliary centre and served as an agency for the reception of requisitions for weather reports and forecasts from and distribution of weather reports to pilots. Arrangements were made for a night pilot balloon ascent and prolonged watch with effect from October 1936. A searchlight was installed at the observatory for determination of height of base of low clouds at night.

The office continued to be housed in rented premises at Karachi. Fire extinguishers were provided at the office, observatory and residential quarters of the observers, and a set of fire rules drawn up.

His Excellency the Governor of Sind was pleased to pay a visit to the observatory during the year.

Kodaikanal Observatory.—The solar and astronomical researches carried on during the calendar year 1936 will be found summarised in the Annual Report of the Kodaikanal Observatory. The routine work of the observatory was carried on as in past years, and co-operation extended as usual to the other observatories under the auspices of the International Astronomical Union.

Dr. T. Royds, Director, who went on deputation to Japan to observe the total Solar Eclipse on the 19th June 1936 with a view to make an accurate determination of wavelengths in the Sun's spectra during partial phase of the eclipse, was successful in obtaining the desired photographs. These were analysed during the year under report.

Daily character figures of solar activity from the photographs obtained at the Kodaikanal Observatory were sent to Prof. Brunner of Zurich. Spectrohelioscopic observations of bright eruptions in the Sun were sent to the Director, Meudon Observatory, Paris, and the Director, Mt. Wilson Observatory. Three positives on glass of some of the important photographs taken at the Kodaikanal Observatory were sent to the Director of Paris Observatory for exhibition at the Discovery Palace.

A report on prominences and the general work of the observatory for 1936 was sent to the Royal Astronomical Society. Statements embodying observations with the spectrohelioscope during the second half of the year 1936 were sent to the Mt. Wilson Observatory, Meudon Observatory, and Prof. Abetti, Arcetri. 78 calcium flocculus spectroheliograms

for the fourth quarter of 1936 were sent to the Solar Physics Observatory, Cambridge.

Studies were made of "Oxygen in Prominences", of the progressive change in inclination of the hydrogen dark markings to the meridian of the Sun and of the lines of hydrogen and calcium in the Fraunhofer spectrum at different points of the Sun's disc.

Facilities were given to Prof. V. Neher of the Californian Institute of Technology in his work at Kodaikanal in connection with the determination of cosmic ray intensities with his special apparatus.

Dr. Royds proceeded, on 12th March 1937, on leave preparatory to retirement. He was connected with the observatory for over a quarter of a century. Under him, the observatory maintained the high traditions set up by his predecessors and made important contributions to Solar Physics.

Meteorological Office, Quetta (temporarily located at Karachi).— This office remained under the charge of an officer deputed from the Indian Meteorological Service but paid by the Royal Air Force, and continued to be located temporarily at Karachi in the premises of the Karachi Meteorological Office.

A general inference and forecast of weather over Sind, Baluchistan and the Punjab together with a local forecast for Karachi was supplied every night except on Saturdays to the Aircraft Depot and 31 A. C. Squadron, R. A. F., Drigh Road, and to the G. O. C., Western Command, Karachi. The inference and forecast (except local forecast) was also supplied by W/T every morning to the Detachment of 31 A. C. Squadron station at Fort Sandeman from the beginning of April 1936. In addition to the routine forecasts, 234 route forecasts, 16 local forecasts for night flying, 52 upper wind forecasts and 10 special weather reports were issued, in response to special requisitions by the Royal Air Force. Of these 14 were special detailed forecasts for the northern Waziristan area issued to the R. A. F. Unit at Miranshah twice daily for supply to WAZIRIFORCE in connection with the military operations near the Khaisora Valley. Special warnings of thunderstorms, duststorms, etc., likely to affect the Aircraft Depot, Drigh Road, were also issued on 10 occasions.

A number of requests from the R. A. F. and military authorities for supply of meteorological data were complied with. R. A. F. officers occasionally visited the office to discuss weather situation in connection with their forthcoming flights. The Meteorologist also visited the Aircraft Depot and 31 A. C. Squadron frequently to keep himself in touch

with their requirements and discuss questions relating to weather and other matters with the officers.

With the assistance of the Officer Commanding, 31 A. C. Squadron, arrangements were made for obtaining meteorological data from aeroplane ascents whenever possible from the detachment at Fort Sandeman. 22 flights were made during the period under review. At Karachi efforts were made to obtain as many aeroplane meteorological flights as possible and the number of flights made during the year was 105. A few records were obtained with a Bosch thermograph fitted on aeroplanes, and a brief report on the trials made with the thermograph was sent to the Headquarters Office.

Most of the instruments salved from the Quetta Meteorological Office after the earthquake were despatched to Poona for repairs and test. The Polar Year Data of Quetta were revised and recopied in final form.

Of the investigational work undertaken by the Meteorologist, one on "Squalls at Karachi" was completed and another on "The study of fogs at the Karachi Air Port" was nearing completion.

Meteorological Office, Peshawar.—This office, which functions as a forecasting office for the Royal Air Force and also as a first-class observatory and an upper air station, continued under the charge of an R. A. F. Meteorological Officer, who is under the technical control of the Director-General of Observatories. A weather report and forecast was issued through R. A. F. W/T at 8 hours daily (except on Sundays and holidays) by this office to all R. A. F. Units stationed in the North-West Frontier Province, the Punjab and Waziristan. A more detailed weather report and forecast for the Peshawar District was issued at 8 hours daily to the Local Group and Squadron Headquarters of the Royal Air Force as well as to the Peshawar District and Brigade Headquarters and the Government House. A daily forecast for inclusion in the programme of Peshawar Broadcasting Station was supplied to the Broadcasting Officer. Forecasts of upper winds were sent daily to the Royal Air Force stationed at Kohat and Risalpur, and special forecasts were issued twice daily during November and December 1936 in connection with operations in Waziristan. 163 route forecasts were supplied to the R. A. F. Units and 8 meteor reports to Artillery units. Numerous enquiries were received from military units, and miscellaneous data and forecasts were supplied to the Anti-Malaria Office, Canal Office, Chemical Defence Department, Agricultural Officers, Public Works Department, etc. Upper air temperature observations were made by the Royal Air Force at Peshawar, Kohat and Risalpur on 340 occasions and transmitted in coded messages to Poona and Karachi.

The Meteorological Officer analysed records of ionisation at Kew Observatory and prepared a note on "The Probable Contribution of Large Ions to Small Ion Counts".

Other Observatories.—The numbers of observatories of various classes are shown in the table below, with the corresponding figures at the end of the previous year :—

Class.	On 31st March 1937.	On 31st March 1936.
I Class	14	14
II Class	173	169
III Class	87	87
IV Class	22	23
V Class	24	24
Non-Instrumental	16	15
*Total	336	332
Non-departmental	62	62

* This total includes the non-departmental observatories whose number is shown separately in the next row.

The records of the non-departmental observatories were scrutinised by this department and in most cases utilised in the daily weather reports and other departmental publications. The importance of these observatories need hardly be emphasised and the co-operation of the Indian States and other public bodies, who maintained them for the furtherance of the study of Indian Meteorology, is much appreciated. Among these may be mentioned the Kingdom of Nepal and the States of Hyderabad, Kashmir, Mysore, Baroda, Bhopal, Travancore, Bahawalpur, Bikaner, Jodhpur, Jaipur, Udaipur, Cooch Behar, Jhalawar, Nawanagar, Ichalkaranji, Kotah and Miraj, the municipalities of Ahmedabad, Ootacamund, Coonoor, Murree and Mussooree and the Agricultural Departments of Bombay, Sind and the Punjab.

VII.—RAINFALL REGISTRATION.

The rainfall data collected by the provincial rainfall organisations, for which the Director General of Observatories is the consulting authority, are published in the provincial rainfall tables, which are collected and issued in a single volume for the whole of India by this Department. The number of stations included in the organisation in the different provinces and the number inspected during the year, together with corresponding figures for the previous year, are given in the following table. On the whole the work of rainfall registration was carried out satisfactorily throughout India.

Rainfall Registration during 1936-37.

No.	Province.	Number of raingauges at the end of			Number of raingauges inspected.		
		1936-37.	1935-36.	Change.	1936-37.	1935-36.	Change.
1	Burma	214	215	—1	212	209	+3
2	Assam	127	128	—1	84	115	—31
3	Bengal	236	236	0	201	206	—5
4	Orissa	74	47	+27(*b*)	71	44	+27
5	Bihar	239	235	+4	216	213	+3
6	United Provinces	273	273	0	255	246	+9
7	Punjab	196	195	+1	170	172	—2
8	Jammu and Kashmir	30	30	0	7	7	0
9	N.-W. F. Province	31	30	+1	30	28	+2
10	Baluchistan	78	78	0	75	67	+8
11	Sind	61	61	0	57	51	+6
12	Rajputana	188	188	0	160	172	—12
13	Bombay	198	200	—2	179	176	+3
14	States in the Bombay Presidency.	79	79	0	47	49(*a*)	—2
15	Central India	123	121	+2	100	106	—6
16	Central Provinces	162	166	—4 (*b*)	159	159	0
17	Berar	42	42	0	42	41	+1
18	Eastern States	47	46	+1	46	45	+1
19	Hyderabad	58	58	0	0	0	0
20	Mysore	75	75	0	75	75	0
21	Coorg	21	21(*a*)	0	21	20(*a*)	+1
22	Madras	488	512(*a*)	—24(*b*)	465	484	—19

(*a*) Revised figures based on information received subsequently.

(*b*) 25 raingauges from Madras and 2 raingauges from the Central Provinces have been transferred to the newly formed Province of Orissa.

Heavy Rainfall Reports.—Heavy rainfall is sometimes so very local that small unrepresented areas can have as much as 10 inches without the present net-work of daily reporting stations conveying the least suggestion of the local deluge. To obtain reports of such local heavy rain promptly for the daily weather report, it was arranged 16 years ago that observers at all raingauge stations at district headquarters in British India as well as in Indian States should telegraph to forecasting centres falls of 5 inches or more. The number of such telegrams received during 1936-37 was 270.

Snowfall Registration.—Information about the distribution and the time of occurrence of snowfall in the Himalayas and the Afghan mountain areas was on the whole tolerably complete, and the thanks of the department are due to the various officers who collected and forwarded the reports.

CONCLUDING REMARKS.

The Meteorological Department owes a large part of its usefulness to the sympathetic assistance it receives from other departments. Officers of various Government departments help the meteorological work as honorary superintendents of observatories or in other capacities. Special mention may be made of the assistance rendered by them in the systematic collection of hail reports from the raingauge stations under them. The India Meteorological Department is greatly indebted to the Imperial Council of Agricultural Research for inaugurating work in Agricultural Meteorology. The department is also very grateful to the Principal of the Agricultural College, Poona, for the facilities given for experimental work at the College farm. The Posts and Telegraphs Department assists this department in the rapid transmission of meteorological information particularly in connection with the warning services.

Weekly telegrams are received from April to October from the Director, Royal Alfred Observatory, Mauritius. These telegrams give valuable information of the weather conditions in the Indian Ocean, and the department is indebted to this observatory for the punctual transmission of the information.

The department is greatly indebted for important information on meteorological conditions prevailing before and during the southwest monsoon to the Controller, Physical Department, Cairo; the Directors of the Observatories at Buenos Ayres and Santiago; the Astronomer Royal, Cape Town; the Director, Department of Agriculture, Zanzibar; the Director, British East African Meteorological Service, Nairobi; the Port Officer, Seychelles; the Commonwealth Meteorologist, Melbourne; Director of Agriculture, Salisbury, Rhodesia; Chief of the Weather Bureau, Washington; the Director, Koninklijk Magnetisch und Meteorologisch Observatorium, Batavia, who also arranges kindly for the daily weather telegrams from Sabang in Sumatra.

Thanks are due to the various ships which wirelessed or posted weather messages (including pilot balloon messages) and to the Marine Superintendents of the British India, Peninsular and Oriental, Scindia, Asiatic, Bombay and Persia Steam Navigation Companies and the Burma Oil, the Anglo-Iranian Oil and Indo-Burma Petroleum Companies for continuing the arrangement under which many captains of their fleets send weather logs to this Department; and to the various ships' officers who sent their marine weather logs direct to this department, and to the various pilots who wirelessed AERMET messages or supplied logs of the weather conditions met with by them during their flight.

Thanks are also due to the Superintendent of the Colombo Observatory for the most useful help he has rendered from time to time in connection with storm warning work and for the useful data of Ceylon stations supplied to this department.

C. W. B. NORMAND,
Director General of Observatories.

POONA,
The 25th July 1937.

APPENDIX A.

THE STAFF OF THE INDIA METEOROLOGICAL DEPARTMENT AS IT STOOD ON 31ST MARCH 1937.

METEOROLOGICAL OFFICE, POONA.

Director-General of Observatories.

C. W. B. Normand, M.A., D.Sc. (Edin.).

General Section.

Meteorologist	A. K. Roy, B.Sc. (Cal.). B.A. (Oxon.).
Assistant Meteorologist	B. N. Sreenivasaiah, M.Sc. (Cal.).
Superintendent	C. P. Venkataramier, M.A. (Madras).
Assistants	5
Stenographers and Steno-typists	4
Cashier	1
Senior Clerk	1
Clerks and typists	12

Weather Section.

Meteorologist	S. K. Banerji, M.Sc., D.Sc (Cal.).
Assistant Meteorologist	U. N. Ghosh, M.Sc. (Cal. (Offg.).
Assistants	2
Clerks and tabulators	13
Draftsmen	5

Observatory Section.

Assistant Meteorologist	Barkat Ali, B.A., M.Sc. (Punjab).
Assistants	2
Inspector of Observatories	1
Clerks	2
Current Weather Observers	8 (at outstations).

Marine Section.

Meteorologist	K. J. Kabraji, B.A. (Hons.), B.Sc. (Bombay), M.Sc., Ph.D. (London).
Assistant	1
Clerk	1

Instruments Section.

Meteorologist	J. M. Sil, B.A. (Cal.), B.Sc. (Engg.) (Boston Tech.) (on leave from 30th March 1937).
Assistant Meteorologist	K. Das, M.Sc. (Punjab), Ph.D. (Lond.).
Assistants	2
Clerks	5
Draftsman	1
Senior Observers	3
Junior Observer	1
Storekeeper	1
Chief Mechanic	1
Mechanics	3
Carpenter	1

Upper Air Section.

Meteorologist	N. K. Sur, D.Sc. (Allahabad).
Assistant Meteorologist	S. S. Lal, M.Sc. (Lucknow and London), D.I.C. (London), A. Inst. P., F.R.Met. Soc. (temporary) (on special duty).
Assistant	1
Clerks	2
Senior Observer	1
Junior Observers	4

Statistical Section and Library.

Meteorologist	S. R. Savur, M.A. (Madras), Ph.D. (Lond.).
Assistant Meteorologist	C. P. Menezes, B.A., B.Sc. (Bombay) (Offg.).
Assistants	3
Librarian	1
Clerks	15
Draftsmen	3

Agricultural Meteorology Section.

Agricultural Meteorologist	L. A. Ramdas, M.A., Ph.D. (Calcutta).
Assistant Meteorologist	V. Satakopan, M.A. (Madras) (Offg.).
Meteorological Assistant	1
Senior Observers	2
Junior Observers	3
Typist	1

Upper Air Observatory, Agra.

Meteorologist-in-charge	G. Chatterjee, M.Sc. (Calcutta).
Meteorologist	S. Basu, M.Sc. (Allahabad).
Assistant Meteorologists	A. K. Das, M.Sc. (Cal.), D.Sc. (Paris).
	S. L. Malurkar, B.Sc. (Mysore), M.Sc. (Cantab.).
	S. P. Venkiteshwaran, B.A. (Hons.) (Madras).
Superintendent	Babu Ram Samnol, B.A. (Punjab).
Mechanical Assistant	Chain Sukh.
Chief Observer	1
Chief Computer	1
Foreman	1
Inspector of Observatories	1
Clerks or Observers	46 (at Agra).
Clerks or Observers	64 (at outstations).
Mechanics	11
Enginemen	3

Colaba and Alibag Observatories, Bombay.

Meteorologist	K. R. Ramanathan, M.A., D.Sc. (Madras).

At Colaba.

Head Clerk	D. L. Chaudhuri, M.Sc. (Cal.).
First Assistant	1
Senior Upper Air Observer	1
Observers	6
Cashier	1
Marine Clerk	1
Typist and Stenographer	1
Junior Upper Air Observers	2

At Alibag.

Observers	2

Alipore Observatory and Meteorological Office, Calcutta.

Meteorologist	S. K. Pramanik, M.Sc. (Lucknow), Ph.D. (Lond.), D.I.C.
Assistant Meteorologists	B. K. Roy, M.Sc. (Cal.).
	S. K. Das, M.Sc. (Dacca and Lond.), D.I.C. (Lond.) F.R.Met. Soc. (Lond.), (temporary).
	C. Ramaswamy, M.A. (Hons.) (Madras) (Officiating).
Superintendent	T. N. Mitra, B.A., B.L.
Chief Observer	B. B. Roy, M.Sc.

Alipore Observatory and Meteorological Office Calcutta—contd.

Meteorological Assistant	1 (on Poona Establishment posted at auxiliary centre at Allahabad
Inspector of Observatories	1
Clerks (Upper Division)	6
Stenographer	1
Senior Observer	1
Clerks (Lower Division)	25
Clerks and Typists (Routine Division)	8 (including two posts of teletypists).
Current Weather Observers	6 (at outstations).
Printer (Press staff)	1

Dum Dum Branch.

Professional Assistant	N. P. Chatterjee, M.Sc. (Cal.).
Senior Observer	1
Junior Observers	3

Meteorological Office, Karachi.

Meteorologist	V. V. Sohoni, B.A. (Hons.), M.Sc. (Bombay).
Assistant Meteorologists	B. N. Desai, B.A. (Hons.), LL.B., M.Sc. (Bombay), Ph.D. (Edin.), F.R.S.E.
	S. Mal, M.Sc. (Benares), D.I.C., Ph.D. (Lond.).
Professional Assistant	H. R. Puri, M.Sc. (Punjab).
Meteorological Assistants	2 (on Poona Establishment posted at auxiliary centres at Jodhpur and New Delhi).
Chief Observer	1
Head Clerk	1
Inspector of Observatories	1
Steno-typist	1
Senior Clerks or Observers	5
Clerks or Observers	16
Junior Clerks or Observers	2
Observers	3 (at outstations).
Clerk (temporary)	1

Solar Physics Observatory, Kodaikanal.

Director	A. L. Narayan, M.A., D.Sc. (Madras), F.I.P.
Assistant Director	Vacant.
Assistants	3
Recorders	4
Mechanic	1
Book-binder	1

Meteorological Office, No. 3 (Indian) Wing, R. A. F., Quetta, temporarily transferred to Karachi.

Meteorologist.	P. R. Krishna Rao, B.Sc. (Mysore) (temporary).
Senior Clerk (temporary)	1
Junior Clerk	1

Meteorological Office, No. 1 (Indian) Group Headquarters, R. A. F., Peshawar.

Meteorological Officer (R. A. F.). . . .	F./Lt. L. H. Starr.
Senior Clerk (temporary)	1
Junior clerks and observers	4

Lahore Observatory.

Chief Observer	1
Clerks or observers	3

Madras Observatory.

Assistant-in-charge.	1
Senior Observer	1
Junior Observers	2

Officers on leave.

T. Royds, D.Sc. (London), F.R.A.S.
S. N. Sen, M.Sc. (Calcutta and London), Ph.D. (London).
V. D. Iyer, B.A. (Madras).

Officer on Foreign Service.

S. C. Roy, M.Sc. (Cal.), D.Sc. (London).

APPENDIX B.

PUBLICATIONS.

The following departmental publications were issued or sent to press during the year :—

I.—Periodical.

1. Daily Weather Reports—
   i. Indian Daily Weather Report (to date).
   ii. Calcutta Daily Weather Report (to date).
   iii. Karachi Daily Weather Report (to date).
2. Weekly Weather Report (to date).
3. India Weather Review, Monthly Weather Report (to date).
4. India Weather Review, Annual Summary, 1935, in five parts—
   i. Introduction.
   ii. Part A.—Summary of Weather with Tables.
   iii. Part B.—Snowfall.
   iv. Part C.—Storms and Depressions.
   v. Part D.—Seismic Records.
5. Daily Rainfall of India, 1934.
6. Monthly Rainfall of India, 1934.
7. Upper Air Data, 1935, in 14 parts—
   i. Parts 1—12.—Pilot Balloon Data and Aeroplane Data for each month January to December.
   ii. Part 13.—Monthly Means of Pilot Balloon Data and Monthly Frequencies of Cloud Direction.
   iii. Part 14.—Sounding Balloon Data.
8. Seasonal Memoranda—
   i. Memorandum on the probable character of the weather in northwest India in January, February and March, 1937.
   ii. Statement of the rainfall and snowfall of northwest India in January, February and March 1936, and a comparison of the seasonal forecast with the actual precipitation.
   iii. Memorandum regarding the probable amount of monsoon rainfall in 1936.
   iv. Memorandum on the rainfall of June and July and the probable amount during August and September 1936.
   v. Statement of actual rainfall in the monsoon season, June to September 1936, and a comparison of the forecasts with actual rainfall.
9. Magnetic, Meteorological and Seismographic Observations made at the Government Observatories, Bombay and Alibag, in the year 1934.
10. Report on the Administration of the Meteorological Department of the Government of India in 1935-36.
11. Report of the Kodaikanal Observatory for the year 1936.

II.—Occasional.

1. Memoirs of the India Meteorological Department—

Vol. XXVI—

Part VII.—Latent instability in the atmosphere revealed by some Indian tephigrams, by V. V. Sohoni and (Miss) M. M. Paranjpe.

2. Scientific Notes—

Vol. VII—

No. 71.—A note on the statistical study of rainfall in the Mysore State, by A. Ananthapadmanabha Rao.

No. 72.—Normal monthly percentage frequencies of surface and upper winds up to 3 km. at Allahabad, Begumpet, Delhi, Sambalpur, Sandoway, Silchar and Victoria Point, departmental.

No. 73.—Daily variations of temperature and pressure at different levels over Agra associated with passage of western disturbances, by S. P. Venkiteshwaran.

3. Kodaikanal Observatory Bulletin—

CVIII.—Summary of Prominence Observations for the first half of the year 1935.

CIX.—Photometric study of the lines of hydrogen and of calcium in the Fraunhofer spectrum at different points of the sun's disc, by T. Royds and A. L. Narayan.

CX.—Summary of Prominence Observations for the second half of the year 1935.

CXI.—A progressive change in the inclination of hydrogen dark markings to the meridian of the sun, by T. Royds and M. Salaruddin.

The following papers, or notes, were contributed to extra-departmental journals :—

1. Das, A. K.

On the temperature of the earth's outer atmosphere and the forbidden OI lines of the night sky spectrum, Gerl. Beitr. Geophys., Bd. 47, 1936, pp. 136—148.

Mechanism of emission of the forbidden lines of neutral atomic oxygen by the night sky, Gerl. Beitr. Geophys., Bd. 49, 1937, pp. 241—251.

The mystery of cosmic radiation, Sci. and Cult., Calcutta, Vol. 2, 1936, pp. 121—123.

2. Desai, B. N. and M. V. Unakar.

Meteorology and Climate of Gujarat. (In Gujarati). Bombay, Gujarat Forbes Sabha, 1936, p. 145.

——B. N. Acharya, A. M. Patel, and——

Conductivity and cataphoretic speed measurements of benzopurpurin 4B Congo red and sky blue F. F., Proc. Ind. Acad. Sci., Vol. 4A, 1936, pp. 503—513.

——C. B. Joshi, P. M. Barve, and——

Importance of dialysis in the study of colloids, part iv, colloidal arsenious sulphide, Proc. Ind. Acad. Sci., Vol. 4A, 1936, pp. 590—602.

——R. R. Khanolkar, P. M. Barve, and——

Condition of sparingly soluble substances in gels, part 1, silver chromate in gelatine, Proc. Ind. Acad. Sci., Vol. 4A, 1936, pp. 468—479.

——G. F. Mankodi, P. M. Barve, and——

Importance of dialysis in the study of colloids, part iii, colloidal Prussian blue, Proc. Ind. Acad. Sci., Vol. 4A, 1936, pp. 480—490.

——G. F. Mankodi, C. B. Joshi, P. M. Barve, and——

A discussion of conductivity and cataphoretic speed measurements of colloidal Prussian blue and arsenious sulphide from the point of view of origin of charge on colloidal particles, J. Univ. Bombay, Vol. 5, 1936, p. 53.

3. Gupta, R. D. (Research Student).

Distribution of temperature and vapour pressure in the neighbourhood of a water-surface, Proc. Ind. Acad. Sci., Vol. 4A, 1936, pp. 275—282.

4. Kabraji, K. J.

On the higher temperatures of rain than of air at Khandala on the Western Ghauts, Gerl. Beitr. Geophys., Bd. 49, 1937, pp. 97—113.

On further observations of rain and air temperatures, Gerl. Beitr. Geophys. Bd. 49, 1937, pp. 402—406.

5. Karve, C. S. (Research Student).

Dependence of ' visibility ' of an object on its apparent size, Curr. Sci, Vol. 4, 1936, pp. 855—857.

6. Malurkar, S. L.

On the polygons formed when any liquid sheet breaks up into cells, J. Univ., Bombay, Vol. 5, 1936, p. 3.

Derivation of a formula for nocturnal radiation and its relation to Angström's formula, Gerl. Beitr. Geophys., Bd. 47, 1936, pp. 357—361.

——and K. T. Kabada.

On the intensity of multiple reflections at a grazing angle from a nearly parallel plate, J. Univ. Bombay, Vol. 5, 1936, p. 5.

——and M. P. Srivastava.

On the differential equation of the instability of a thin layer of fluid heated from below, Proc. Ind. Acad. Sci., Vol. 5A, 1937, pp. 34—36.

7. Paranjpe, M. K. (Research Student).

The convection and variation of temperature near a hot surface, part 1, the dust-free or dark layer in relation to surface convection, Proc. Ind. Acad. Sci., Vol. 4A, 1936, pp. 423—435.

The convection and variation of temperature near a hot surface, part 2 applications of interferometry to the measurements of temperature and temperature gradients very close to a hot surface, Proc. Ind Acad. Sci., Vol. 4A, 1936, pp. 639—651.

8. Rajagopalan, N. (Research Student).

A note on the rainfall of Kadur, Bangalore and Chitaldrug districts in the Mysore State, Curr. Sci., Vol. 5, 1936, p. 307.

9. Raman, P. K.

Studies in atmospheric radiation : a discussion of some observations of nocturnal radiation made at Poona and Sinhagad, Proc. Ind. Acad. Sci., Vol. 4A, 1936, pp. 243—253.

10. Ramdas, L. A. and R. K. Dravid (Research Student).

Soil temperatures in relation to other factors controlling the disposal of solar radiation at the earth's surface, Proc. Nat. Inst. Sci. Ind., Vol. 3, 1936, pp. 131—143.

——and M. S. Katti (Research Student).

Agricultural meteorology, studies on soil moisture in relation to moisture in the surface layers of the atmosphere during the clear season at Poona, Ind. J. Agric. Sci., Vol. 6, 1936, pp. 1163—1200.

——B. N. Sreenivasiah and P. K. Raman.

Variation in the nocturnal radiation from the sky with zenith distance and with time during the night, Proc. Ind. Acad. Sci., Vol. 5A, 1937, pp. 45—55.

11. Royds, T. and A. L. Narayan.

Density of calcium and hydrogen at different levels in the sun, Curr. Sci., Vol. 5, 1936, pp. 294—295.

Oxygen in solar prominences, Curr. Sci., Vol. 5, 1937, pp. 531—532.

12. Savur, S. R.

On Bayes' problem, Curr. Sci., Vol. 5, 1937, pp. 385—386.

A new solution of a problem in inverse probability, Proc. Ind. Acad. Sci., Vol. 5A, 1937, pp. 222—234.

The median as a statistic, Curr. Sci., Vol. 5, 1937, pp. 419—421.

13. Srivastava, M. P.

Turbulence, Sci. and Cult., Calcutta, Vol. 2, 1937, pp. 377—383.

GIPD—L147DGofObPoona—25-10-37—550.

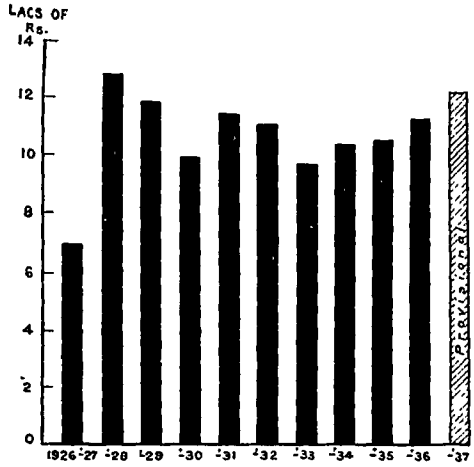


FIG. 1 EXPENDITURE.
(EXCLUDING EXPENDITURE ON TELEGRAMS AND ENGLISH CHARGES.)

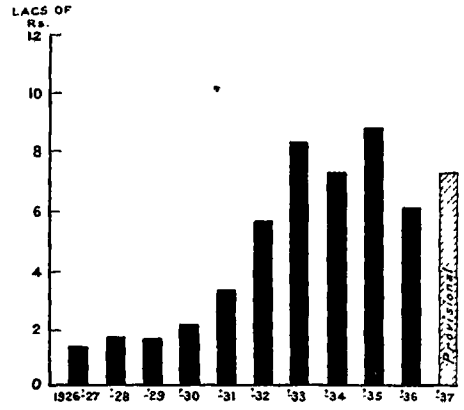


FIG. 2 EXPENDITURE ON TELEGRAMS.

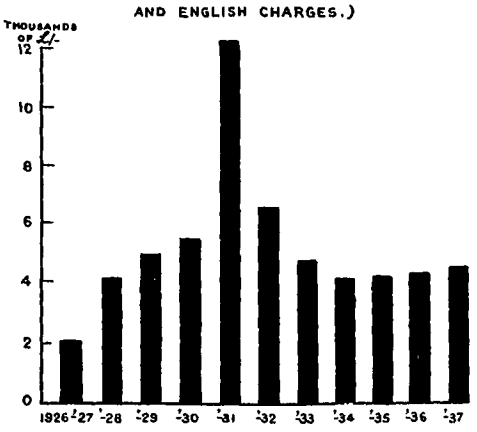


FIG. 3. GRANTS FOR PURCHASES BY INDIA STORE DEPT, LONDON (i.e. ENGLISH CHARGES.)

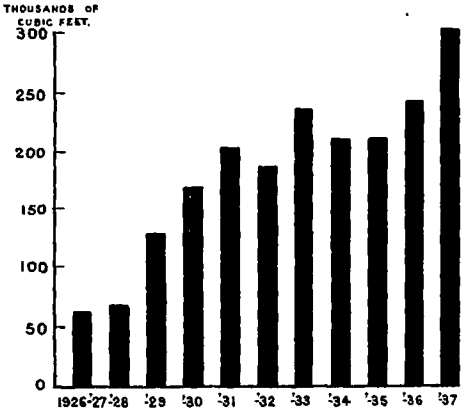


FIG. 4. PRODUCTION OF HYDROGEN FOR BALLOONS.

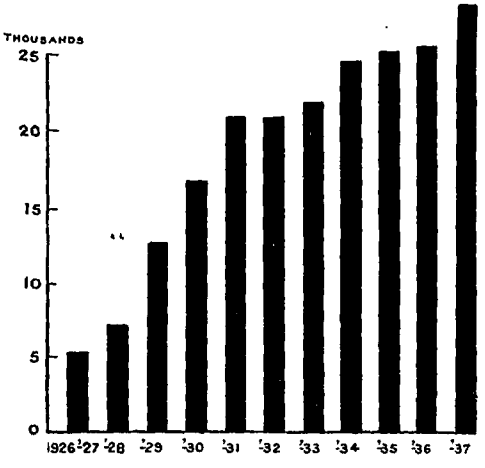


FIG. 5. NUMBER OF PILOT BALLOON ASCENTS.

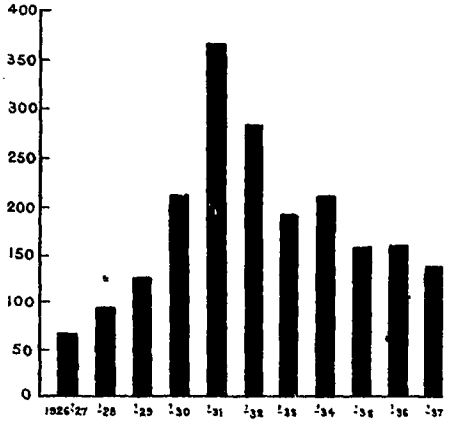


FIG. 6. NUMBER OF SOUNDING BALLOON ASCENTS.

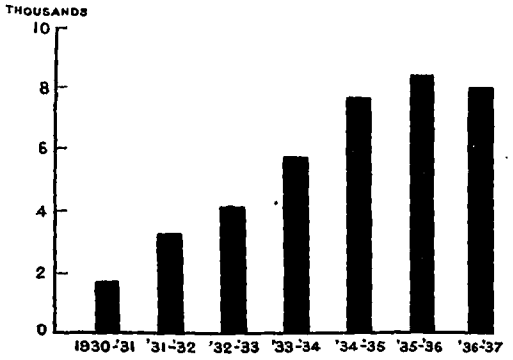


FIG. 7. WEATHER FORECASTS FOR AVIATION.

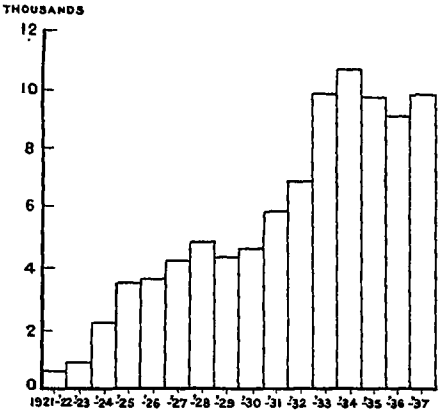


FIG. 8. WIRELESS WEATHER MESSAGES FROM SHIPS.

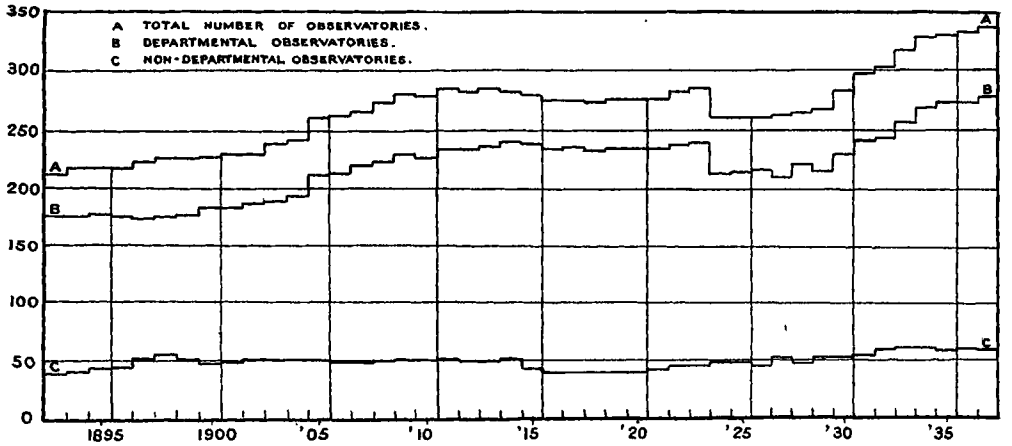


FIG. 9. SURFACE METEOROLOGICAL OBSERVATORIES.

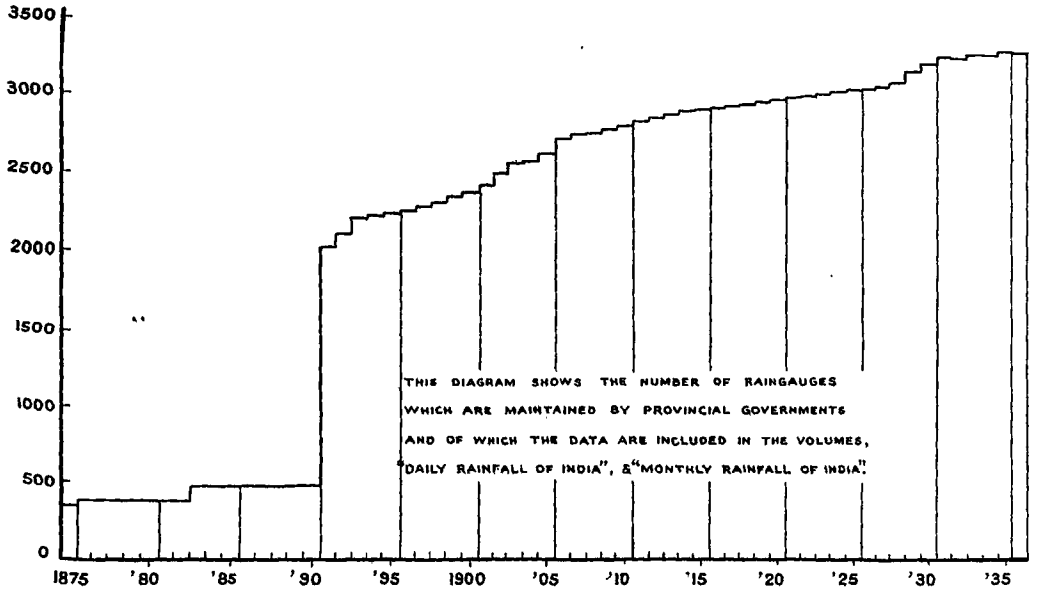


FIG. 10. DEVELOPMENT OF PROVINCIAL RAINFALL ORGANISATION IN INDIA.

DGO. 26. 38.
620.

Report on the Administration of the Meteorological Department of the Government of India in 1937-38.

PUBLISHED BY THE MANAGER OF PUBLICATIONS, DELHI.
PRINTED BY THE MANAGER, GOVERNMENT OF INDIA PRESS, NEW DELHI,
1938.
Price annas 12 or 1s.

1 140

Report on the Administration of the Meteorological Department of the Government of India in 1937-38.

PUBLISHED BY THE MANAGER OF PUBLICATIONS, DELHI.
PRINTED BY THE MANAGER, GOVERNMENT OF INDIA PRESS, NEW DELHI.
1938.

List of Agents in India from whom Government of India Publications are available.

(a) PROVINCIAL GOVERNMENT BOOK DEPOTS.

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BOMBAY :—Superintendent, Government Printing and Stationery, Queen's Road, Bombay.

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(b) PRIVATE BOOK-SELLERS.

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Aero Stores, Karachi.*
Banthiya & Co., Ltd., Station Road, Ajmer.
Bengal Flying Club, Dum Dum Cantt.*
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Bhawnani & Sons, New Delhi.
Bombay Book Depot, Charni Road, Girgaon, Bombay.
Book Company, Calcutta.
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Burma Book Club, Ltd., Rangoon.
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Cambridge Book Co., Booksellers, New Dak Bungalow Road, Patna.
Careers, Mohini Road, Lahore.
Chatterjee & Co., 3, Bacharam Chatterjee Lane, Calcutta.
Chukervertty, Chatterjee & Co., Ltd., 13, College Square, Calcutta.
City Book Club, 98, Phayre Street, Rangoon.
Das Gupta & Co., 54/3, College Street, Calcutta.
Dastane Brothers, Home Service, 456, Ravivar Peth, Poona 2.
Delhi and U. P. Flying Club, Ltd., Delhi.*
Educational Book Depot, Mahal Road, Nagpur.
English Book Depot, Ferozepore.
English Book Depot, Taj Road, Agra.
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English Book Store, Abbottabad, N.-W. F. P.
Faqir Chand Marwah, Peshawar Cantonment.
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H. L. College of Commerce; Co-operative Stores, Ltd., Ahmedabad.
House of Knowledge, Booksellers and Publishers, Pallagraharam P. O., Tanjore.
Hyderabad Book Depot, Chaderghat, Hyderabad (Deccan).
Ideal Book Depot, Rajpur Road, Dehra Dun.
Imperial Book Depot and Press, near Jama Masjid (Machhliwalan), Delhi.
Imperial Publishing Coy., Lahore.
Indian Army Book Depot, Dayalbagh, Agra.
Indian Army Book Depot, Daryaganj, Delhi.
Indian Book Shop, Benares City.
Indian School Supply Depot, Central Avenue, South, P. O. Dharamtala, Calcutta.
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Keshao Book Stall, Khadibazar, Belgaum.
Kitabistan, 17-A, City Road, Allahabad.
Krishnaswami & Co., Teppakulam P. O., Trichinopoly Fort, Messrs. S.
Lahiri & Co., Calcutta, Messrs. S. K.
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London Book Co. (India), Arbab Road, Peshawar, Murree, Nowshera, Rawalpindi.
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Malik & Sons, Sialkot City.
Mathur & Co., Messrs. B. S., Chatur-Vilas, Patta, Civil Lines, Jodhpur (Rajputana).
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Modern Book Depot, Bazar Road, Sialkot Cantt.
Mohanlal Dossabhai Shah, Rajkot.
Mohendra Brothers, Lashkar, Gwalior State, Messrs.
Nandkishore & Bros., Chowk, Benares City.
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Newman & Co., Ltd., Calcutta, Messrs. W.
Oxford Book and Stationery Company, Delhi, Lahore, Simla, Meerut and Calcutta.
Parikh & Co., Baroda, Messrs. B.
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Punjab Religious Book Society, Lahore.
Raghunath Prasad & Sons, Patna City.
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Ram Krishna Bros., Opposite Bishrambag, Poona City.
Ram Narain Lal, Katra, Allahabad.
Ramesh Book Depot and Stationery Mart, Kashmere Gate, Delhi
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Roy Chowdhury & Co., 72, Harrison Road, Calcutta, Messrs. N. M.
Saraswati Book Depot, 15, Lady Hardinge Road, New Delhi.
Sarcar & Sons, 15, College Square, Calcutta, Messrs. M. C.
Sarkar & Co., Ltd., 18, Shama Charan De Street, and 6, Hastings Street, Calcutta, Messrs. P. C.
Sharada Mandir, Ltd., Nai Sarak, Delhi.
Standard Bookstall, Karachi.
Standard Bookstall, Quetta.
Standard Book Depot, Lahore, Dalhousie and Delhi.
Standard Law Book Society, 69, Harrison Road, Calcutta.
Tara & Sons, Razmak (India), Messrs. B. S.
Taraporevala Sons & Co., Bombay, Messrs. D. B.
Thacker & Co., Ltd., Bombay.
Thacker, Spink & Co., Ltd., Calcutta and Simla.
Tripathi & Co., Booksellers, Princes Street, Kalbadevi Road, Bombay, Messrs. N. M.
Uberoy, J. C., Journalist, Printer and Publisher, Jayen House, Alexandra Road, Ambala.
Universal Book Depot, 58, Hazratganj, Lucknow.
University Book Agency, Kacheri Road, Lahore.
Upper India Publishing House, Ltd., Literature Palace, Ammuddaula Park, Lucknow.
Varadachary & Co., Madras. Messrs. P.
Venkatasubban, A., Law Bookseller, Vellore.
Wheeler & Co., Allahabad, Calcutta and Bombay Messrs. A H.
Young Man & Co. (Regd.), Egerton Road, Delhi.

* Agent for publications on Aviation only.

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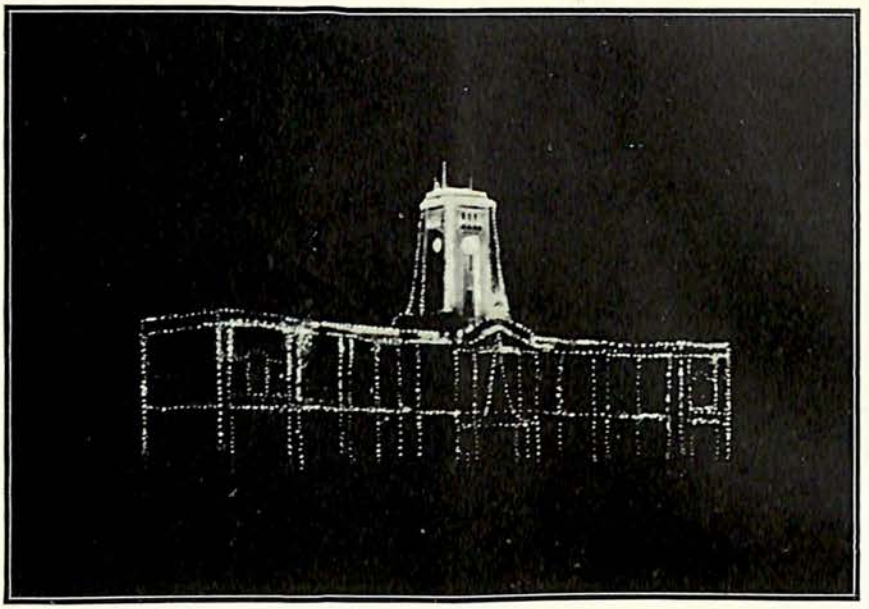
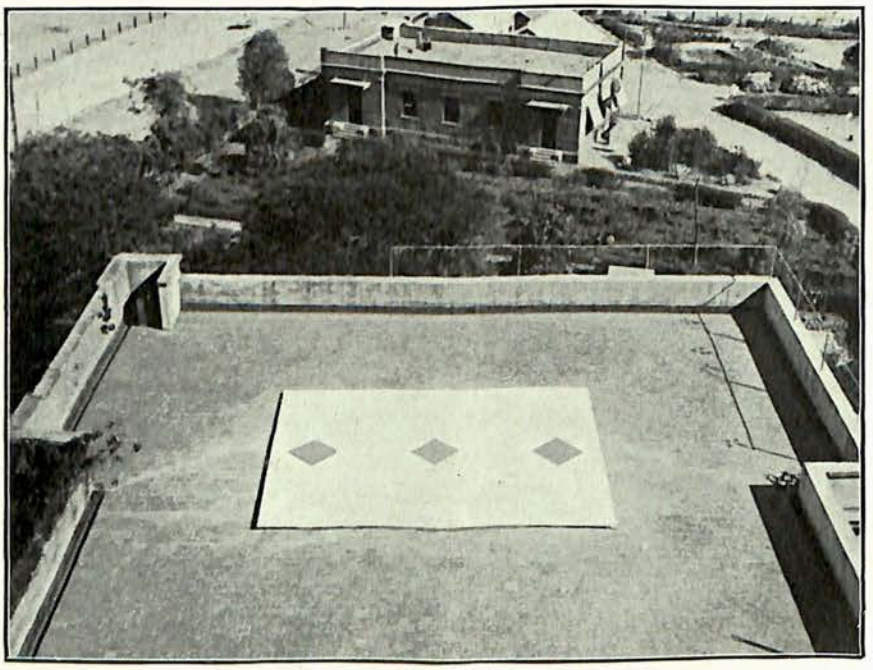


The Meteorological Office at Poona illuminated on the occasion of His Majesty the King-Emperor's Coronation, May 1937.



A visual signal of red diamonds on a white background is displayed on the roof of the Poona office to notify to the passing airmail plane on its way to Bombay the height of low cloud at Bombay. The picture above (foreground) shows the signal when the cloud height at Bombay was about 800 ft.

Report on the Administration of the Meteorological Department of the Government of India in 1937-38.

I.—CHIEF FEATURES OF THE YEAR.

1. **The late Mr. J. H. Field, C.S.I.**—The department has to record with great regret the death on May 19, 1937, at the age of 64 years, of Mr. J. H. Field, C.S.I., the former Director General of Observatories. Mr. Field joined the department in 1904 and retired in March 1928; he played a distinguished part in building up the department to its present state. A brief account of his career with a photograph was given in the Administration Report for 1927-28, issued soon after his retirement. Mr. Field laid the foundation for the investigation of the upper air over India; the resulting aerological organisation with its central observatory at Agra which he created is the greatest monument to his memory. His regime as Director General was short, a little over three years; it coincided with the coming of civil aviation to India and thanks to his forceful personality, convincing arguments, impressive enthusiasm and power of persuasion, he was able within a short period to achieve a number of developments of far-reaching and permanent importance to the department. He secured a permanent home for the headquarters of the department at Poona and a substantial increase in the gazetted staff both at headquarters and at Calcutta and brought about the first real extension of pilot balloon work in India and its neighbourhood—a step of great significance to aviation as well as to general forecasting and investigational work.

Mr. Field's scientific papers consist mainly of memoirs on his upper air research and on the exposures of thermometers in India. He also indicated a method of forecasting the winter rainfall in north-west India from upper air data—a method which has since been found to be of great practical use.

Even after he retired from official meteorological service, Mr. Field did not give up his interest either in Meteorology or in the progress of the India Meteorological Department. The investigation he undertook in 1929 at the request of the Air Ministry into the cause of flying accidents near the Rock of Gibraltar is a very important piece of work which bears testimony to his characteristic thoroughness. Letters written by him to individual members of the department up to a month or two before his death showed how great a well-wisher of the department he remained and with what keen interest he followed its fortunes and development.

Apart from his achievements for the department, Mr. Field will be remembered for the tireless thoroughness and the critical acumen which characterised his work, both scientific and administrative, and with which he inspired all those who came in contact with him. His fine and

sturdy character, honesty and integrity won him universal respect. In his death the department has lost a true friend and meteorological science a fine experimental meteorologist.

2. The chief features of the work during the year are briefly indicated in this chapter of the report. Fuller details are given in subsequent chapters.

3. **Fundamental Improvements.**—The year under review saw the accomplishment of certain projects of fundamental importance which have been under consideration for some years past. The most important of these was the daily preparation, with effect from 1st April 1937, of an afternoon weather chart at Poona. This removed a long-felt want and the cost was more than covered by the saving which was effected by the adoption of a shorter code for weather telegrams. The Headquarters office is now able to issue two forecasts a day. The afternoon synoptic map which is now printed in the Indian Weather Report has enhanced the value and interest of the Report to the general public and to the meteorological services of other countries. Another important development was the increased participation on India's part in the international diffusion of weather data. The short wave aeronautical wireless stations at Karachi and Calcutta began from 1st August 1937 to issue, twice daily, regional broadcasts of synoptic data. The newly started Burma Meteorological Department followed suit and commenced broadcast of data of stations in Burma from October 1937. The wireless station at Calcutta picks up these data as well as the synoptic broadcasts issued from Bangkok and makes them available to other offices in India. The construction of a short wave wireless station at Poona was taken in hand by the Posts and Telegraphs Department. When this is completed, it will be possible to start the overdue and much desired collective and regional synoptic issues from Poona.

4. **Consideration of further improvements and plans for the future.**—While effect was being given to the abovementioned improvements, considerable thought was also devoted to future new lines of advance and general improvement of the organisation. The recommendations of a meteorological conference held in Delhi in December 1936 were studied in detail and proposals based thereon were submitted to Government for sanction. These proposals included, among others, the reopening of a forecasting office at Delhi and a certain amount of reorganisation of the whole department, including the transfer of the Upper Air Office from Agra to Delhi. The Government of India approved all the proposals in principle but it was learnt with regret early in April 1938 that they were obliged to postpone actual sanction of them in view of an unexpected deterioration in the financial situation. It is hoped, however, that Government will find it possible to sanction these facilities fairly soon. The department's needs in connection with the Further Civil Aviation Capital Programme, which provided for developments in aviation anticipated in the near future, were examined. The departmental Officers' Conference, which had not been held for the past few years owing to financial stringency, met at Calcutta during Christmas week and discussed questions aiming at immediate improvements in the

service rendered to the public, seamen and airmen; other subjects concerned modes of improving internal practice and procedure and investigations and the lines on which these should be conducted by the department. The Director, Burma Meteorological Department, attended by invitation and took part in the discussions at the Conference. His presence was valuable particularly for discussions on questions where uniformity of practice between Burma and India is needed.

5. **Services to Aviation.**—As in past years, the further extension and improvement of meteorological service to aviation continued to demand attention. New current weather stations were opened in connection with the projected seaplane service and the extension of air routes in south India. Current weather work was also started at a few stations with the help of aerodrome personnel. Night balloon and current weather work were started at three stations in the Persian Gulf and at Juhu. The introduction of the Empire Air Mail Scheme and associated developments in internal air services involved considerable extension and revision of existing arrangements. A routine system of exchange of weather reports between the principal aerodromes on the Karachi-Madras air route was introduced on the institution of aeronautical wireless stations on that route.

6. **The new Burma Meteorological Service.**—The meteorological service of Burma which came into being on the separation of Burma from India took over the administrative control of all observatories in Burma concurrently with the separation but the technical control of the observatories as well as the forecasting responsibility with respect to the Burma area remained with this department for three months longer. From 1st July 1937 all work in relation to Burma, excepting that of storm warning to shipping in Burman waters and to Burman ports and of supply of hydrogen to pilot balloon observatories at Burma, was taken over by the new service.

7. **Broadcasts to shipping.**—Of other important matters may be mentioned the introduction, at the instance of the Royal Indian Navy, of an arrangement to broadcast synoptic data, as well as weather bulletins for the whole of the Indian waters from the Navy Wireless Station at Bombay for the benefit of shipping. These were additional to the broadcasts issued from the civil wireless stations at Bombay and Calcutta.

8. **International Meteorology.**—Correspondence with international bodies continues to increase. Detailed consideration of the resolutions of the various Commissions of the International Meteorological Organisation, of the regional conferences held at Lusaka and Hongkong and of the meetings of the International Meteorological Committee and Commissions held at Salzburg during September 1937 entailed much work, which, though additional, can hardly be called abnormal as similar or heavier items are likely to recur in future years also.

9. **Routine activities and special investigations.**—The department carried on as usual its marine and inland warning work and other

normal activities in the various centres. A fair amount of progress was maintained in investigational work. In addition to the sounding balloon ascents at Agra, Poona and Madras, arrangements were made, with the co-operation of the Government of Mysore, to release sounding balloons from Bangalore. As a first step in the programme of intensive upper air surveys during cyclonic storms, several special ascents of sounding balloons were also made at other stations, *e.g.*, Alipore, Gaya, Sambalpur, Waltair, Jubbulpore, Jodhpur, Lahore and Allahabad, during the monsoon season, the main aim being to study the properties of the air masses which take part in depressions of the south-west monsoon. A total of over 250 sounding balloons were thus let off and 131 retrieved. Considerable attention was devoted during the year to the subject of the sources of energy of storms and simplified graphical methods of calculating available energy were devised, special attention being given to the role of water vapour as a source of energy. Of other important subjects of which a study was made may be mentioned the general circulation of the atmosphere over India and neighbourhood, the aerological data collected in Bengal during the nor'wester season of 1929, the meteorological data collected by aeroplane ascents during the Polar Year, the thermodynamics of dust-storms, and vertical currents in the atmosphere disclosed by pilot balloon ascents. Attention was also directed to a further improvement in the existing formulæ used for long-range forecasting of rainfall.

The Agra Observatory continued to study a variety of problems of practical interest. Experiments conducted to remove the zero shift of temperature in a Dines' meteorograph were very largely successful. Further work was done on the development of the calibration apparatus for large meteorographs that are used with larger balloons or on aeroplanes; and the construction of a wet and dry bulb meteorograph to record photographically on an aeroplane was taken in hand. At the Colaba and Alibag Observatories, investigations were conducted on several subjects in geophysics, atmospheric electricity and terrestrial magnetism, for example, on the focal depths of some earthquakes in India and the neighbourhood, on the seismological data of the Quetta earthquake of 1935, on the effect of near lightning discharges on magnetometers, and on the diurnal variation of the hourly ranges of magnetic elements. The officers at Karachi were engaged in studies of thunderstorms, while the R. A. F. Meteorologist there made a study of fog and of upper air temperatures and humidities over Karachi. The Meteorological Officer at Peshawar continued his work on the ionisation records obtained at Kew Observatory. At Kodaikanal, studies were completed of the observations collected in the 1936 Eclipse expedition to Japan and a note was published on the presence of oxygen in Solar prominences. A 13-foot prismatic spectrograph of the Littrow type was constructed for the purpose of undertaking a systematic study of the contours of selected lines in different parts of the sun's disc and particularly in sunspots. Arrangements were also made for the simultaneous measurement of the magnetic field and temperature of sunspots.

10. **Agricultural Meteorology.**—The Agricultural Meteorology Section at Poona made further progress with its studies on a number of problems including, among others, the heat and moisture balances at the earth's surface, the interaction between climate and crops, methods of controlling the micro-climate for practical purposes and the prediction of minimum temperatures from prior meteorological conditions. Particular mention may be made of the application of sampling technique to the measurements of the growth and yield of crops side by side with observations on their climates.

11. **Publications.**—The routine publications of the department were issued as usual. In addition to notes and papers published by the officers and staff of the department in extra-departmental journals, foreign as well as Indian, 7 Scientific Notes or Memoirs had been sent to press by the end of the year, while several other papers were being considered for publication. The department began the issue of a new publication entitled "Monthly Frequency Tables" on the lines recommended by the International Commission for Air Navigation. It was also decided to issue with effect from 1st January 1938, a quarterly bulletin of seismic data relating to India.

12. **Warning messages.**—The number of weather forecasts issued to aircraft from the different forecasting centres totalled 7,665. Besides these, 10,000 upper wind reports and more than 17,000 reports on current weather, including warnings of adverse weather and development thereof, were supplied to pilots from different stations along the air-route. Nearly 11,500 warning messages were issued to ports and 3,500 messages to shipping at sea in connection with disturbed weather on the seas while warning messages of inland heavy rain, intimation of rainfall, high winds and frosts numbered about 12,000.

II.—MARINE METEOROLOGY.

Storm Warnings.—Storm warnings for the Bay of Bengal and the surrounding areas continued to be issued from the Meteorological Office at Calcutta and those for the Arabian Sea area from the Headquarters Office at Poona.

The latest weather information was supplied as usual to shipping at sea by means of wireless weather bulletins issued from coastal radio stations twice daily on ordinary undisturbed days and more frequently on days of disturbed weather. The additional arrangement, introduced last year at the request of the Royal Indian Navy, of broadcasting weather bulletins relating to the Arabian Sea from the Navy Wireless Station at the Bombay Fort was continued. In addition, the weather bulletins sent daily by Calcutta Meteorological Office to Matara for broadcasting were also sent to the Navy Wireless Station, Bombay, for broadcast from there as an experimental measure from 10th May 1937. The system of broadcast of weather bulletins was examined at a conference with Naval officers held at Poona in September 1937 and a further modification was introduced with effect from 1st November 1937. From this date, the Navy Wireless Station, Bombay, arranged to broadcast, as a permanent measure, all weather bulletins in respect of both the

Bay of Bengal and the Arabian Sea on three different wave lengths, and the transmission of weather bulletins by land line telegrams to Aden and Matara for broadcast was discontinued. The latter stations, however, arranged to pick up the Bombay signals and rebroadcast them.

The total number of broadcast messages issued by the Calcutta Office to shipping in the Bay of Bengal during the year was 2,045 as against 1,859 during the previous year; and the number issued from Poona to shipping in the Arabian Sea was 1,445 as against 1,267 during the previous year.

Services to ports around the Bay of Bengal.—There was no change in the system of storm warnings to ports. The Calcutta Office continued to be responsible for warning 34 ports around the Bay, including those in Burma as the Burma Meteorological Department has not yet taken over storm warning duties in respect of their area. Warnings were issued for 28 periods of disturbed or suspicious weather and probability of thunder squalls. Of these, 16 developed into depressions 7 of which intensified further and became cyclonic storms. An account of the severe cyclonic storm of the last week of September 1937 may be of interest. The storm had its origin in the passage of a low pressure wave from the east across Tenasserim into the Andaman Sea, leading to the formation of a depression near Diamond Island by the 26th morning. Moving northwestwards at first and northwards later, it intensified rapidly and was a severe cyclone by the 28th morning when it was situated near Saugor Island and had a pressure deficiency of at least 0·70″ near its centre. With the approach of the cyclonic storm, winds of gale and hurricane force prevailed in the northwest angle of the Bay and southwest Bengal. D. V. Dumayne, anchored in the Kalpi Roads about 30 miles from Calcutta, reported heavy cyclonic weather associated with terrific rain squalls, winds of gale force and high seas continuously from about 11 A.M. to midnight of the 28th. The storm passed close to Calcutta on the 28th evening. Although it weakened to some extent thereafter, it still remained a storm and was centred near Burdwan on the 29th morning. Moving northwestwards and weakening at the same time, it filled up over Bihar on the 30th September.

The storm was responsible for widespread and heavy rain in and around Bengal and also in Bihar. Balurghat in Dinajpur district gauged 19″ of rain on the morning of the 1st October while Fatehpur in Faridpur district had 14″ on the 27th September.

According to newspaper reports, the storm was responsible for widespread damage in west Bengal and Bihar. Large tracts of land were flooded. A large number of huts were destroyed and hundreds of men rendered homeless. Several boats were sunk in the rivers and numberless trees uprooted. Telephone and telegraphic lines were put out of commission leading to considerable dislocation of communications. Vehicular traffic, both railway and road, was interfered with considerably and steamer and boat traffic in the port of Calcutta was held up. Calcutta and its suburbs suffered heavily as a result of the storm.

Associated with the storm, a water spout, probably a tornado, was reported to have been observed in the neighbourhood of Calcutta. The following report from a newspaper regarding this is of interest :—

"An entire village and part of another within the Boinchitollah Union, 24-Perganas, were destroyed and cattle numbering about 100 were killed as a result, it is reported, of a water spout that originated near about Garia station on the Eastern Bengal Railway yesterday (Wednesday, the 29th September, 1937) and passed over a section of the Union shortly after midday.

This phenomenon, it is stated, was never before witnessed by the villagers who were all awe-stricken at the sudden appearance of it and dumb-founded at the scene of devastation that it left behind.

The villagers in describing it said that it was like a column of black whirling water forcing ahead at great speed with heavy winds and with terrific sound resembling that of aeroplanes when flying low.

It was first noticed near Garia station and in the twinkling of an eye and without giving any warning the column moved towards Kusumpur village, brushed its borders razing two huts to the ground and hurling the inmates and cattle in the huts up into the air. The column then moved forward at great speed and passed through another village, Anandapur, where it destroyed no less than 35 huts rendering hundreds of people homeless. The inmates of the huts were hurdled high up into the air. Many of them fell down unconscious on the water-logged surface of earth. The water spout finally passed over on elevated plot of land where temporary sheds had been erected by the Union Board (Boinchitollah) to shelter villagers who had been rendered homeless by the flood and storm of Tuesday and demolished them all. Finally it went out of sight perhaps subsiding into the waters of the salt lakes.

Messrs. Kumaresh Chandra Ray Chowdhuri and Prakash Bhattacharjee, the Sanitary Inspectors of the Union, who were engaged in rescue work were also caught by the moving column and thrown into the air."

The usual circular letters were issued to port authorities asking for their opinions and suggestions regarding the warnings issued to them during the year. Replies were received from 26 and showed that nearly all of them were satisfied with the warnings received by them and the system adopted. The total number of warnings issued to ports by the Calcutta Office was 4,094 as against 5,230 in the previous year.

Services to Arabian Sea ports.—The system of storm warnings to ports remained unchanged and warnings for the Arabian Sea ports continued to be issued as usual by the Poona Office. Two ports were added to the warning list during the year bringing the total number to 41. Warnings were issued for 46 periods of disturbed or suspicious weather. Of these, two developed into depressions and one into a cyclonic storm.

Twenty-seven port officers sent in their annual returns regarding the warnings received by them. All of them expressed satisfaction with the warnings issued and desired no change in the system. The number of warning messages issued to ports by the Poona Office was 7,355 as against 4,380 during the previous year.

Exchange of information with ships at sea.—The chief sources of marine data are wireless messages from ships at sea and extracts from

weather logs of ships calling at the principal ports. During the year 13,145 radio messages were received from ships in the Bay and the Arabian Sea as against 9,992 received during the previous year. This large increase is gratifying as it indicates growing co-operation on the part of ships' captains and their appreciation of the role of these messages in the creation and maintenance of an efficient storm warning service. It is not possible to name here every steamship that sent messages, but those that sent 75 messages or more during the year are listed below along with the number of messages received from each.

Name of the ship.	No. of messages.	Name of the ship.	No. of messages.
1. Akbar	108	25. Jalapalaka	95
2. Aronda	90	26. Jalavijaya	105
3. Badarpur	164	27. Jalamohan	85
4. Baloeran	102	28. Jalapadma	106
5. British Architect	135	29. Jalavihar	82
6. Bahadur	92	30. Jalaveera	75
7. British Sovereign	83	31. Jalatarang	131
8. Chyebassa	117	32. Jaladuta	126
9. Chilka	110	33. Jalaputra	106
10. Ekma	120	34. Jalaratna	129
11. Ethiopia	120	35. Karoa	95
12. Erinpura	130	36. Mashobra	124
13. Egra	102	37. Masimpur	184
14. Gazana	81	38. Marnixvanstaldegonde	82
15. Gairsoppa	86	39. Multan	75
16. Golconda	118	40. Ormara	117
17. Goalpara	84	41. Pasha	79
18. Garmuala	97	42. Rajula	100
19. Haresfield	96	43. Rohna	91
20. Jalarashmi	111	44. Rahmani	155
21. Jalarajan	96	45. Singu	145
22. Jalaganga	99	46. Shewdagon	104
23. Jalajyoti	99	47. Surada	96
24. Jalabala	75	48. Yenangyang	75

Pilot balloon messages were received by wireless occasionally from a few H. M. ships, the total number being much smaller than during the previous year.

The second principal source of marine data is the log extracts collected by marine clerks in Calcutta and Bombay and the various steamship agencies. The British India, the Peninsular and Oriental, the Scindia, the Asiatic, the Bombay and the Persia Steam Navigation Companies, and the Burma Oil, the Anglo Iranian Oil and the Indo-Burma Petroleum Companies have standing arrangements with a number of their ships' captains to copy out and despatch extracts from weather logs on two kinds of forms which are supplied to them for use during ordinary weather and during disturbed weather respectively. A total of about 4,800 logs was collected during the year.

Synoptic data for ships' use.—The issue by wireless of synoptic data of selected stations for the benefit of shipping in Indian waters was continued during the year. Certain special demands for synoptic data led to an arrangement with the Royal Indian Navy whereby such broadcasts were issued from their wireless station at the Bombay Fort in addition to the other issues from the civil coastal Radio stations at Bombay and Calcutta and the Navy Wireless Station at Matara. This arrangement was started as an experimental measure at first and on its being found satisfactory was adopted as a permanent measure from 1st November 1937. From this date synoptic data for the Arabian Sea and the Bay of Bengal including the Ceylon area, consisting of observations of 45 selected land stations and 10 ships are now telephoned daily at about 11 A.M. from the Poona Office to the Navy Wireless Station at Bombay. On the permanent introduction of this arrangement, the broadcast from the Navy Wireless Station at Matara was found unnecessary and hence discontinued.

A scheme to issue evening synoptic data by broadcast at about 9 P.M through the Navy Wireless Station at Bombay was under consideration.

III.—AVIATION METEOROLOGY.

Two changes of importance which affected this department's jurisdiction in regard to services for aviation took place during the year. The first was the establishment of an independent meteorological service in Burma on her separation from India. From 1st July, 1937, the new Burma Meteorological Service became responsible for the weather reports and forecasts issued to aviators flying over Burma. The other important change was that, with the opening of a meteorological centre at Basra under the Iraq Meteorological Service, forecasting for regions or routes west of Jask/Sharjah was taken over by the Basra Office from 1st March 1938. The responsibility of the India Meteorological Department on the main international route across India therefore now extends from Sharjah/Jask on the west to Akyab on the east.

As in past years, the Meteorological Offices at Karachi and Calcutta shared the responsibility for the supply of weather reports and forecasts on the main trans-India route as well as on other routes over northern

India, while the Poona Office issued forecasts to airmen in southern India. On the main trans-India air route, forecasts and weather reports were distributed according to the routine system introduced some years ago. On other routes, the system of preparing and handing over route forecasts in respect of each individual flight continued to be in vogue. Weather reports and forecasts were supplied not only to the regular air mail services but to various individual fliers, members of Indian Flying Clubs and R. A. F. squadrons on requisition.

Certain developments of considerable importance to aviation took place during the year and have already been mentioned under the Chief Features. The most outstanding of these was the daily preparation, with effect from 1st April 1937, of an afternoon weather chart at Poona. This is of considerable help to aviation in south India and has supplied a long-felt want although, even with this improvement, the organisation in India is still short of the standards set by the International Air Convention. The chart has made it possible for the Poona office to issue a second forecast in the evening. Another new item was the broadcast of synoptic data twice daily from the aeronautical wireless stations at Karachi and Calcutta. It is hoped to make similar regional issues later on from Delhi and Poona, so that anyone picking up all these four as well as the broadcasts from Rangoon which the Burma Meteorological Department has arranged will be able to draw fairly detailed weather charts of the Indian region both morning and evening. Further important improvements in the service, both to civil and R. A. F. flying, recommended by the Delhi Conference of 1936 included the re-opening of a forecast centre at Delhi; these had been agreed to in principle by Government but unfortunately, a later decision resulted in the postponement of these items in view of a deterioration in the financial situation. It is hoped that Government will find it possible to sanction these items soon.

A representative of this department attended the Conference held at Gwalior in July 1937 to discuss the organisation required there in connection with the sea-plane service. The annual conference of R. A. F. meteorological officers held in April 1937 submitted recommendations for improving the meteorological organisation in northwest India from the point of view of the R. A. F. The departmental Officers' Conference held at Calcutta in December also considered a number of points of practical importance to aviation.

The routine arrangements for the exchange of weather reports along the trans-India air route worked satisfactorily. On the establishment of aeronautical wireless stations on the Karachi-Madras route, the routine system was partially extended to that route also, and, from 1st December 1937, upper wind reports as well as current weather observations taken at fixed hours at principal observatories on this route are being distributed daily by wireless to the main aerodromes on the route. The system has also been extended in a very limited form to the Madras Colombo route. The introduction of the Empire Air Mail Scheme and associated developments in internal air services involved considerable extension of activities. Current weather stations were started during the

year at Raj Samand and Gwalior for the benefit of the flying boats, and sanction was received to expand these stations into pilot balloon stations from 1st April 1938. The schedules of supply of meteorological reports on the Bahrein-Karachi route and on the feeder route between Karachi and Lahore were suitably revised in order to fit in with the new time tables and with the increased frequency of the services consequent on the inauguration of the Empire Air Mail Scheme. Arrangements were made for the supply of weather reports (including current weather information by landline telegrams from certain stations) to the planes flying on the new Madras-Colombo, Trivandrum-Trichinopoly, Bombay-Delhi routes operated by Tata Sons Ltd.

Of other improvements effected during the year may be mentioned the installation of standard lamps for visibility measurements at night and of searchlights for cloud height measurements at a few more stations, the start of night balloon and current weather work at Bahrein, Sharjah, Gwador and Juhu, the shift of the pilot balloon station from Bellary to Bhuj to serve better the needs of the Karachi-Ahmedabad air route, and the introduction of arrangements for current weather work by aerodrome personnel at Cawnpore and in a limited way at Multan, Hyderabad (Sind) and Uterlai. Arrangements were also made to receive at Gaya the weather reports and forecasts relating to the Allahabad-Calcutta route and for their exhibition at that aerodrome. Towards the end of the year, the responsibility for receiving and posting weather notices at Dum Dum was partly taken over by the meteorological staff and arrangements were in progress to shift the pilot balloon observatory now housed at Alipore to that station. A number of questions of vital importance to aerodrome-planning, like detailed recording and study of winds and visibility at a number of stations, was considered and schemes drawn up. Detailed observations of visibility and cloud height were taken at the seaplane bases at Raj Samand and Gwalior and were analysed. Arrangements were made to hand over to the I. T. C. A. pilots on days of their night halts at Calcutta simple weather charts showing the weather situation at 17 hrs. at stations along and near the air routes over which they would be flying next day.

This department suggested to the International Meteorological Organisation during the year an amendment of international codes and specifications in respect of the issue of warnings of dangerous phenomena and their improvement. After considerable discussion the International Meteorological Committee agreed to certain amendments which substantially meet the view-points of this department. Subject to the amendments being finally approved by the International Commission for Aerial Navigation, the department has decided to adopt the international forms of the code for current weather reports from 1939.

As in past years, a number of candidates for Pilot's B licence were trained and examined in Meteorology at departmental centres. The total number trained was 28, of whom 27 were examined. In addition, a few candidates for the Air Ministry Second Class Air Navigators

licence were given facilities to prepare for their examination in Meteorology. A course of lectures was delivered at Poona on the "March of Seasons in India" to the Tata Air Mail pilots.

Forecasts were issued for several special flights including flights of several R. A. F. squadrons.

It was gratifying to find that the service was found useful by airmen and appreciated. The following remarks made by some fliers may be quoted :—

From the report on Delivery Flight of Singapore III K. 8859 to Singapore—August, 1937 :—

> "General notes on weather reports and winds—No difficulty was experienced in obtaining weather reports on the flight out. The Service for the supply of meteorological information in India was found to be most efficient. Very accurate and frequent broadcasts of pilot balloon reports and general weather reports can be intercepted while in flight, giving all the information required.
>
> The reports received throughout were reasonably accurate and complete. The only unexpected phenomenon encountered which was not predicted by the weather report for the route, was the sudden change in direction through about 110° of the very strong wind in the Persian Gulf."

The Senior Air Staff Officer, Headquarters, Royal Air Force, wrote as follows :—

> "The Air Officer Commanding, Air Forces in India, wishes to thank you, and the Meteorological Departments under your control most sincerely for the excellent meteorological arrangements made in connection with the flights of Royal Air Force Aircraft which flew across the trans-India route to and from Singapore during the period January—March, 1938. It is fully realised that these additional flights cause a certain amount of inconvenience, and that in some cases, special arrangements have to be made. Your ready co-operation in this matter is, therefore, all the more appreciated. Officers and airmen of both this and Iraq Commands are unanimous in their appreciation of the meteorological organisation on the trans-India air route and I hope you will convey the Air Officer Commanding's thanks to all concerned."

Pilots of the regular air services continued to send in their weather logs and occasionally sent AERMET messages from the air, which, it is hoped, will increase in number in future years. The Q-code was also used appreciably in requisitioning meteorological reports.

The total number of aviation forecasts, as distinct from aviation weather reports, issued during the year was 7,665, of which Karachi was responsible for 4,187, Calcutta for 2,015, Poona for 1,048, Peshawar for

249 and the R. A. F. Meteorological Office, Karachi, for 166. Altogether about 13,000 routine current weather reports and 10,000 upper wind reports were issued from stations on the various air routes, most of them being distributed by wireless. In addition, nearly 4,000 special current weather reports in answer to requisitions by aircraft and 600 voluntary warnings of adverse weather and improvement thereof were issued by the chain of current weather stations along the trans-India air route.

The pamphlet on "Meteorological Organisation for Airmen" needed revision on account of the important changes arising from Burma separation, the introduction of routine arrangements over southern India air routes and the modification of the international pilot balloon code. The revision was taken in hand.

IV.—SQUALL, HEAVY RAINFALL AND FROST WARNINGS.

Inland weather warnings and forecasts.—The majority of officers, to whom warnings of heavy or untimely rain and strong winds on land were issued, were district officers and officers of the Irrigation, Railway, Police, Telegraph and other departments. In addition to these, officers of agricultural departments, a number of district officers and some private agriculturists were warned of conditions favourable for occurrence of frost. The total number of addresses on the Poona warning list was 225 and on the Karachi list 13. In the case of Calcutta, the inland warning list consists not only of officers and interests such as mentioned above but also of river ports, river stations and police stations which receive special warnings for storms and occasionally for squalls associated with Nor'westers. During the year the Calcutta list had on it 152 officers including 12 officers of the Telegraph Department, 8 river ports, 13 river stations and 58 police stations. In addition, 415 district and police officers in Bengal receive great danger warnings from the Calcutta Meteorological Office in respect of cyclones likely to affect their areas. The R. A. F. Meteorological Officer at Peshawar issued rainfall warnings to the Executive Engineer, Canals Division, Peshawar, whenever occasion demanded. Apart from these specific warnings to individual officers, the Daily Telegraphic Weather Summaries contained heavy rainfall and cold wave forecasts and all subscribers thereto and others to whom the information became accessible thus received these warnings. In addition to warnings sent to those on the standing lists referred to above, warnings were also issued in response to special requisitions.

The system of issue of warnings to Collectors in the Bombay Presidency and to provincial Agricultural Officers which was introduced last year at the instance of the Government of Bombay and the Imperial Council of Agricultural Research respectively was in operation during the year. 27 officers of the United Provinces Agricultural Department were added to the cold wave warning list during the year. While the recipients of the warnings expressed general satisfaction, the real difficulty pointed out by them—and one in which improvement is needed if warnings should be fully effective—was the absence of facilities for quick dissemination of the information to the villages.

During the year under review, the Meteorological Office at Calcutta issued 8,530 inland warnings, including special weather bulletins for rivercraft, warnings of probability of thundersqualls in Bengal and great danger warnings to the District and Police officers. The Poona Office issued 3,240 inland warnings including those for low temperature and occasional special messages, while the Karachi Office issued 156 warnings. Over 800 heavy rainfall telegrams were sent direct to various officers by departmental meteorological observatories.

Reports on the working of the inland warning system were received from 32 officers on the Poona warning list and 132 officers on the Calcutta list and all of them expressed satisfaction with the warnings received by them. A number of Collectors of the Bombay Presidency informed this department that the warnings received by them could not be disseminated to the villages in time and suggested that the warnings should be sent to the *Mamlatdars* of *talukas* direct. One Collector communicated a *Mamlatdar's* suggestion that, during the monsoon season, it would be more useful to give intimation of no rainfall than to give intimation of heavy rain. There was yet another suggestion that, when rainfall over forty-eight hours is likely a second message after twenty-four hours would be of great use if it could indicate whether the rainfall is likely to continue. All these suggestions as well as a few criticisms which were received regarding individual warnings were carefully examined with a view to see how far the service could be improved. On the whole, the system worked satisfactorily and gave satisfaction to the interests concerned. It may not be out of place to quote from a few of these reports. The Collector of Colaba wrote—

> "The intimations of 22nd June 1937 and 24th June 1937 did special good to the people of Mahad as there was a flood on these days and damage to life and property was saved a good deal by the advance intimations.
>
> At other places in the District, the intimations were found to be very useful and the system of giving advance intimations of weather conditions is worth adopting permanently."

The Executive Engineer, Upper Division, Eastern Jumna Canal, Saharanpur wrote—

> ".....The forecasts were substantially correct in almost all cases."

The Dewan of Rajpipla wrote—

> ".....Warnings were of great use."

The Officer-in-charge, District Police Station, Diamond Harbour wrote—

> "The warning telegrams were very useful inasmuch as, when received, these were immediately told out to the public specially to the boatmen who in turn secured the boats safely and thus many accidents were averted.....".

V.—OFFICES AND OBSERVATORIES.

A list of the staff of the India Meteorological Department as it stood on the last day of the year under review is given in Appendix A.

Headquarters Office, Poona.—The principal items of scientific work done in this office have been briefly mentioned under the Chief Features. Ten meetings of the colloquium were held during the year and were devoted as usual to discussions which were opened by a member of the staff or outside scientific workers who took as a special subject his own original work or a recent important paper published elsewhere. The Silver Jubilee Session of the Indian Science Congress was held, conjointly with the British Association, at Calcutta during the first week of January 1938 and 3 departmental officers were deputed on duty to attend the meetings of the Congress. In addition, a number of other departmental officers who had come to Calcutta for the departmental Officers' Conference in December 1937 stayed on, on their own account, to attend the Session. Dr. C. W. B. Normand presided over the Physics and Mathematics Section of the joint Meeting and gave an address on "The Sources of Energy of Storms".

The New Year Honours 1938 brought the decoration of C.I.E. to Dr. C. W. B. Normand.

The department participated in the All-India Exhibition of Arts and Industries held at Lahore and sent a number of exhibits to show the working of the department.

The activities of the different Sections of the Headquarters office are briefly described below :—

General Section.—This section deals with matters relating to the administration of headquarters and sub-offices including such items as budget, accounts, establishment, general registry, administrative and quasi-technical matters relating to aviation organisation and matters involving fresh expenditure, as well as arrangements for the co-ordination of work.

The year under review was one of unusually heavy work on account of the various new developments, chiefly those relating to aviation and separation of Burma, and new schemes for improvement already referred to under the chapters on the Chief Features and Aviation Meteorology. The scheme of preparing the second chart at Poona involved the examination of much detail in order to effect the necessary savings by which it was to be financed. The synoptic broadcast scheme was another which involved scrutiny of a number of details and considerable correspondence with the Burma Meteorological Department, the Civil Aviation Directorate and the sub-offices, as the times of broadcast, the stations included in the broadcasts, etc., had to be so adjusted as to provide the maximum benefit to the various meteorological offices concerned and the maximum saving in expenditure on landline weather telegrams so that money could be diverted to other schemes of development.

The separation of Burma involved considerable correspondence with the new Burma Meteorological service which had necessarily to be helped in a number of ways in the beginning. Various financial and other adjustments between India and Burma on account of the separation of the meteorological services took considerable time and attention. Watch and control of the telegraphic expenditure of the department involved heavy work, the expenditure during the year under this head having been affected by the enhancement of telegraphic rates between Burma and India and also other important factors like the curtailment of the length of weather codes, the introduction of the short codes later than intended, preparation of the second chart at Poona, adoption of the RTP system for telegrams from Burma observatories to India and *vice versa*, enhancement of charges for copies of ships' radiotelegrams coming to forecast centres, a small saving arising as a result of introduction of the synoptic broadcast scheme and so on. The introduction of routine arrangements for exchange of weather reports on the Karachi-Colombo air route, arrangements for new services like the Bombay-Delhi and Trivandrum-Trichinopoly air services, revision of schedules of supply of weather reports on various routes as a consequence of the Empire Air Mail Scheme, special arrangements for flying boats, introduction of current weather work at Raj Samand, Gwalior, Multan, Cawnpore and Gaya and of night balloon and current weather work at Bahrein, Gwador, Sherjah and Juhu, investigation of complaints regarding working of the meteorological service to aviation were some of the important items to which attention had to be devoted in connection with aviation. Considerable correspondence took place with the Director of Civil Aviation in India in regard to the building programmes at aerodromes now in progress or already sanctioned and also regarding buildings that will be needed in future in connection with further developments in aviation. The preparation of a list of schemes of improvement for the next few years, the formulation of definite proposals on the basis of the Delhi Conference including the opening of a forecast centre and a reorganisation of the department, the preparation of the minutes of the departmental officers' Calcutta conference and consideration of its recommendations were special items of work. Correspondence with international bodies and consideration of the Resolutions of the Regional Meteorological Conferences and of the meetings of the International Commission for Aeronautical Meteorology and the International Meteorological Committee have also to be listed amongst the special items.

A revised pamphlet on the Functions and Organisation of the India Meteorological Department including changes on account of Burma separation and the new routine system for exchange of weather reports on the south Indian air routes was ready but its issue was withheld pending the changes and developments like reorganisation and starting of Delhi Office which had been proposed to Government.

The examination of the reports of local audit of departmental offices, the application of various rules to recruitment of staff, etc., added to the routine work of the section.

Weather Section.—This section is responsible for the issue of warnings to shipping and ports in the Arabian Sea, of weather reports to aircraft in the Peninsula, of daily weather telegrams which appear regularly in the newspapers and of the Daily, Weekly and Monthly Weather Reports and for the preparation of portions of the Annual Summary for the India Weather Review. It also issues warnings to individual interests in respect of heavy rainfall and low temperatures for the whole country excepting northeast India and Sind. Details regarding the marine, aviation and inland weather warnings issued by this section have been incorporated in the relevant foregoing sections of this report.

The most important change which took place in the section's work was the preparation of a daily afternoon chart—a development which has been eagerly looked forward to for a number of years. The Poona Office has hitherto had to base its weather reports and forecasts to airmen on weather charts prepared once in 24 hours—a system which was very inadequate for aviation needs and which does not obtain in other parts of the world, where civil aviation has developed. The second chart now enables the Poona Office to issue an up-to-date weather report in the evening and a forecast for aircraft taking off in the early morning. The scheme depended on economies which a curtailment in the lengths of the weather codes was to provide; consequently, on the scheme being sanctioned, an interim short code was introduced from 1st May 1937. Later on, *i.e.*, from 1st January 1938, this interim code was replaced by a permanent seven-group code which was framed on the lines of the International Code; this new code, unlike the older codes in the department, does not provide for check figures. The afternoon synoptic map is now a regular feature of the Indian Daily Weather Report. The scheme has been introduced for 2 years in the first instance, but it is hoped that it will be made permanent after the experimental period.

Consequent on the formation of a separate meteorological service in Burma, the All-India Weather Summary telegrams issued from Poona ceased to include the summary and forecast of weather over the Burma area from 1st July 1937. From the same date, detailed description of weather conditions over Burma was omitted from the various periodical, weather reports, namely, the Indian Daily Weather Report, Weekly Weather Report, Monthly Weather Report, etc. The data of important Burma stations, however, continued to be included in these publications.

The responsibilities of the section in regard to aviation underwent considerable increase as a result of extensions of air services in south and Central India. Consideration of the Resolutions of the Lusaka and Hongkong Regional Meteorological Conferences concerning synoptic weather work and of the Resolutions of the International Commission for Synoptic Weather Information and the International Meteorological Committee constituted a special item of work. Resolutions of the International Commission on Projection for meteorological charts were considered and, when adopted, will involve the use of Mercator's Projection for the synoptic charts in the Indian area.

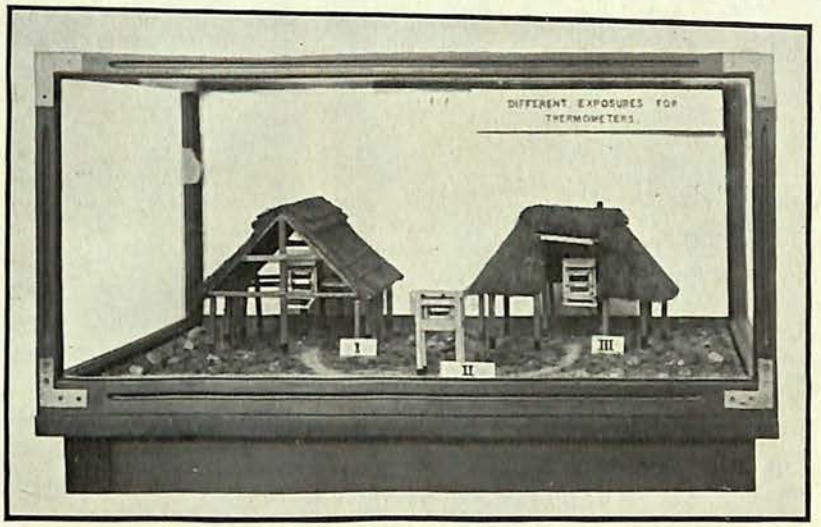
There was an increase in the number of officers on the warning list mainly due to the addition of 27 officers of the United Provinces Agricultural Department on the cold wave warning list. 4 candidates for pilots B licence were trained and examined in elementary meteorology. A course of lectures was delivered to the Tata air mail pilots who were also given practical demonstrations in forecasting.

Observatories Section.—This section continued to administer and arrange for the inspection of departmental observatories in central and southern India and also to supervise generally the administration of surface observatories which are in the immediate control of sub-offices. The sanction of the second daily weather chart at Poona involved the raising of most of the observatories in the Peninsula to second class status. The Government of India sanctioned the establishment of temporary third class observatories in the Consulates at Kandahar and Jalalabad. The observations at Jask were hitherto taken by the wireless staff, but on the Iranian Government taking over charge of the wireless station arrangements were made with the local agents of the B. I. S. N. Co. for the continuance of observations at that station.

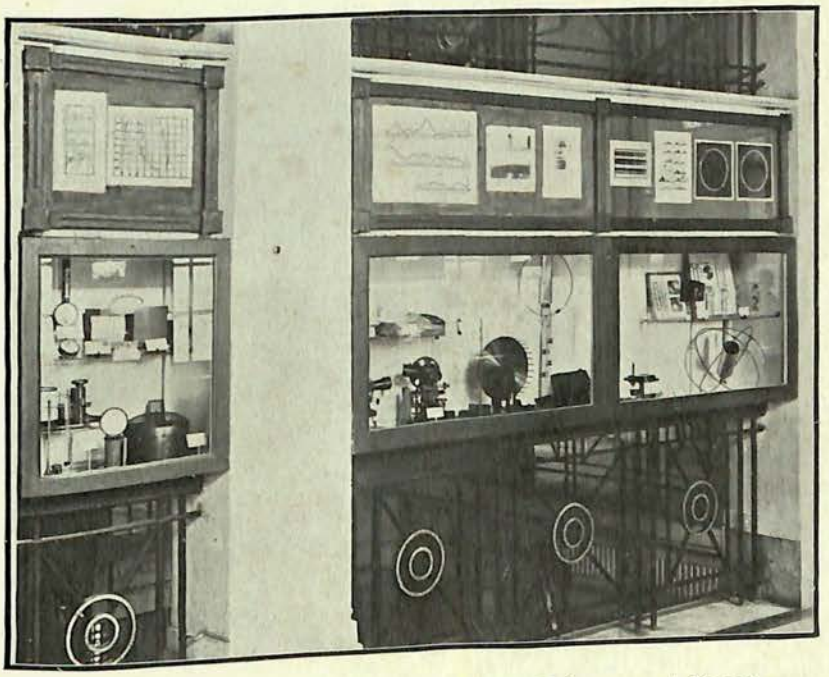
Of observatories under the control of the Poona Office, 48 were inspected during the period. A new and revised edition of the departmental Cloud Atlas was brought out and distributed to the observatories.

It was decided to change the time of morning observation at Baluchistan stations to 8 hrs. local time and the time of afternoon observation in south Baluchistan from 12 hrs. G. M. T. to 17 hrs. I. S. T. This step has brought the observational hours in Baluchistan in line with the rest of India. Hitherto, south Baluchistan and north Baluchistan differed in their times of observation and both differed from the system prevailing elsewhere in India.

Instruments Section.—The section continued to be responsible for the purchase, test, standardisation and repair of meteorological instruments and the issue of these instruments as well as forms and stationery to the departmental surface observatories. During the period under review, 984 instruments were purchased, 937 instruments, mainly of the old types, were recalled from observatories and replaced, and 1,378 instruments issued to the departmental observatories. 18 instruments were loaned to outside organisations. 892 instruments were tested and 325 instruments repaired and reconditioned. I. M. D. Station type Kew Pattern barometers were introduced at 23 stations. A new Dines P. T. anemograph was got installed at Madras to replace the present Beckley instrument there. Certain old types of instruments at Kodaikanal and Peshawar were replaced by the latest patterns. A sturdier type of I. M. D. electrical anemometer was made and issued to S. P. V. Lady Fraser. The work relating to installation of searchlights and alidades was continued at several stations on the air routes for observations of cloud height at night; the installation is now complete at 7 stations. In connection with current weather observations at night, 3 electrical I. M. D. anemometers manufactured at Poona have been installed at New Delhi, Karachi and Jodhpur.



A model exhibited in the Museum at the Meteorological Office at Poona to illustrate different exposures for thermometers. I. The Madras type of shed. II. The Stevenson screen. III. The Bengal type of shed.



A few show cases in the Meteorological Museum at Poona.

With a view to find the difference between the catches of the M. I. O. and the London M. O. pattern raingauges the two years' comparative data collected at Alipore were analysed. A report on the comparative observations undertaken at Agra and Poona of temperature and humidity in Stevenson screens of the India Meteorological Department pattern and the new Air Ministry pattern was sent to the Director, London Meteorological Office. A two-feet wind tunnel was installed in connection with the testing of anemometers, etc. A large number of exhibits were added to the museum and suitable lighting arrangements inside the showcases provided.

Assistance was rendered to the Burma Meteorological Department to draw up its first indent of stores to be purchased in England. In order to help that department to start its work, a few instruments, spare parts, samples, forms, etc., were supplied on loan.

52 enquiries from outside organisations about meteorological instruments were replied to. About 1,500 visitors on 111 different occasions were shown round the observatory and the museum.

Marine Section.—The normal duties of the section, *viz.*, the co-ordination of the work of collection, examination and study of ships' weather logs and of maintaining contact with shipping interests as well as of issue of instructions for observations at sea were carried on as usual. The introduction of the scheme of issue of broadcasts of synoptic data and weather bulletins from the Navy Wireless Station at Bombay, which has been referred to already under the Chief Features, formed an important item of work in the section during the year. Schemes to establish a system of Indian selected ships and to issue a departmental periodical of interest to seamen were under consideration during the year. A new pamphlet on the "Code of Storm Warnings to Ganges Delta Ports and River and Police Stations" was printed and distributed. The base maps for the proposed climatological atlas of Indian waters were prepared. The "Memorandum regarding logs for the Meteorological Department" was condensed to serve as a card for ready reference and printed copies distributed suitably. Procedure for the scrutiny of barograms from the ships was laid down in the form of a technical instruction circular. Arrangements were made to inform foreign services when the comparison of their barometers in their national ships showed large differences from those at neighbouring Indian stations. Various resolutions of the regional Meteorological Conferences and the International Commissions affecting marine meteorology were considered. The data of rainfall observations made on board H. M. I. S. "Investigator" during the last survey season were examined. In response to a request from this department, the Dutch Meteorological Service arranged to issue instructions to their ships for taking observations, while in the Indian seas, according to this department's requirements. The London Meteorological Office schedule of hours of observations for H. M. ships in Indian waters was returned with this department's suggestions for modification. Arrangements were made to supply log forms and technical instructions to British tankers plying in Indian

waters and carrying Indian crews. As usual, essays in Meteorology by cadets of the I. M. M. T. S. Dufferin were judged, and a suitably inscribed aneroid barometer was sent to the Captain Superintendent, Dufferin, for presentation to the winning cadet. The minutes of the meteorological conference held at the Naval Office, Colombo, in October 1937 were considered. Statistics of ships' wireless messages received and broadcast during the second half of 1937, were prepared and despatched to the President, Sub-Commission, Radiometeorological Organisation of the Oceans, Paris.

Upper Air Section.—Sounding balloon work was carried on as usual at Poona and Madras; besides these, as already stated under the Chief Features, several special ascents were made in collaboration with the Upper Air Observatory, Agra, at a number of stations for the study of depressions in the southwest monsoon. With the co-operation of the Government of Mysore, sounding balloons were let off from Bangalore during the season when the recovery of balloons released from Madras is not satisfactory. In all 85 soundings were arranged by this section at the different stations and 53 instruments were recovered. Measurements of height of base of clouds were made at Poona every night during the monsoon season by means of a searchlight.

Pilot balloon and other data of Region D for 1935 were forwarded to the Secretary of the International Aerological Commission. The departmental pilot balloon code was suitably revised, mainly with a view to shorten the length of the code. The publication of "Monthly Frequency Tables" giving the statistics of surface and upper winds, height of base of low clouds and visibility in a form laid down by the International Commission for Air Navigation was commenced. The publication has met with favourable reception from a number of flying clubs in India.

A paper on the "Aeroplane data collected during the Polar Year" was published. A paper on aerological data collected in northeast India during the nor'wester season of 1929 was in the course of publication. A note on the thermodynamics of duststorms was published. A detailed paper on the latter subject and paper on vertical currents in the atmosphere disclosed by pilot balloon ascents were submitted for publication.

Statistical Section and Library.—The duties of this section include statistical work connected with the issue of seasonal forecasts and with climatology; the care of the library, the editing and distribution of departmental publications and the supply of general meteorological information in reply to enquiries are also included in the work of the section.

Statistical work to improve the existing forecasting formulæ was continued as in the previous year.

2 memoirs and 5 scientific notes were sent to press during the year and several other papers were received and were being considered for publication. New editions of the various departmental weather codes,

of the departmental cloud atlas and of relative humidity tables were published. 346 requests for climatological, meteorological and astronomical information were received and replied to.

The routine activities of the climatology branch and the usual advisory functions of the Director General of Observatories with regard to the registration of rainfall, inspection of raingauges and preparation of provincial tables were carried on as usual.

Arrangements were made to receive the monthly "Climat" broadcasts (mean monthly data) from various centres. Monthly normals of pressure, temperature and rainfall for the 30-year period 1901—30 for the 16 stations of India and Iran included in the monthly broadcasts from Cairo were prepared in accordance with the recommendation of the International Climatological Commission and forwarded to various meteorological organisations, from whom were received in return similar normals for stations whose data are broadcasted by them.

Two long-range forecasts of monsoon rainfall were issued in June and two more in August.

Agricultural Meteorology Section.—Sir John Russell, F.R.S., who had inspected the section in December 1936 expressed approval of the programme of work and of the results achieved by the section in his printed report to Government. Sir John's conclusion was that "the need for investigation in agricultural meteorology is beyond question and Poona is the obvious place for the work. It should now be on a permanent basis".

In December 1937 the section was visited by Prof. R. A. Fisher, F.R.S. Some stimulating discussions on statistical problems in Agricultural Meteorology were arranged during his visit. Prof. Fisher was particularly interested in the work being done by the section on "Precision Observations" (*i.e.*, observations on the development of crops during growing season and finally the estimate of yield by sampling) using modern sampling technique. He suggested that such observations should be recorded at selected centres in India and made recommendations to that effect to the Imperial Council of Agricultural Research. Proposals on the subject were discussed informally with the Council later.

The investigations on the various processes involved in the disposal of solar radiation and rainfall at the surface of the ground were continued at the Central Agricultural Meteorological Observatory. Amongst other new investigations, those on the capillary rise of water through the soil from a water table below, transpiration from plants, the exchange of water vapour between soils, plant materials, seeds, etc., and the surrounding air layers, may be mentioned. The studies on the interaction between climate and the plant-world (*i.e.*, the climates of different crops as controlled by the general weather and modified by plant population, density of foliage, intensity of air movements, etc.) were continued. Thanks to the kind co-operation of the Agricultural College it was possible to improve the facilities for experimental work by adding a neighbouring plot to the grounds of the observatory.

Amongst new instruments, useful for investigations in agricultural meteorology, designed or made during the year under review, may be mentioned a simple percolation gauge designed by the section and now manufactured by the Scientific Instruments Co., Ltd., Allahabad, and a sensitive and robust portable galvanometer evolved by the Laboratory Apparatus Works, Poona, at the instance of the section. The latter instrument is proving very useful for the measurement of plant, soil and air temperatures under field conditions.

On the statistical side special attention was devoted to the sampling studies on the growth and yield of crops both at Poona and at a few other centres with the co-operation of agricultural officers. The analysis of the daily rainfall during May and June over a number of areas along the west coast of the Peninsula during the past sixty years was continued in connection with a study of the mode of onset of the south-west monsoon. A note on the prediction of low temperatures during cold waves from a knowledge of prior meteorological conditions by using statistical methods was published, and another on the frequency of days with hail-storms in India was completed. Further work was done on the computation of the frequency of heat waves. The investigations of the frequency of phenomena like floods and droughts in India and of the yield of cotton in the experimental farms at Jalgaon and Akola in relation to weather were completed.

The Agricultural Meteorologist attended the meeting of the Crops and Soils Wing of the Board of Agriculture held at Lahore in November last and read a paper on "Crop protection from the effects of weather". The discussions at this meeting and the visit to Lyallpur soon after threw much light on a number of problems in agricultural meteorology.

The section continued to maintain liaison between agriculture and meteorology in the manner indicated in previous reports.

A research student was awarded the M.Sc., degree (Bombay) on the strength of a thesis on soil temperatures prepared under the direction of the Meteorologist. About twenty original papers and notes were prepared or published describing the results of the experimental and statistical investigations made during the year by the staff and research students attached to the section.

The section was fortunate in getting the kind co-operation of the staff of the Agricultural College in work on a number of subjects. The Agricultural Chemist joined in the investigation of variations in total nitrogen in the soil in relation to climate. The Plant Pathologist was interested in the problem of cereal rusts in relation to climate and help was given to him in the selection of a site for setting up a rust-research station in the Bombay Presidency. The co-operation extended by the Crop Botanist at Karjat in the precision studies on rice deserves special mention.

Upper Air Observatory, Agra.—This observatory controls the work of the pilot balloon stations of the department and maintains supplies of hydrogen, balloons and other stores to all these stations. On the establishment of an independent meteorological service in Burma the administrative control of pilot balloon observatories in Burma was transferred to that department with effect from 1st April 1937 and the

technical control with effect from 1st July 1937. The Agra Observatory, however, continued to supply hydrogen to observatories in Burma in accordance with an arrangement agreed to between the Governments of Burma and India.

The total number of pilot balloon observatories in the department was 32 at the end of the year. The pilot balloon observatory at Bellary was shifted to Bhuj in order to serve the needs of the Tata Sons' Karachi-Madras air service. The Quetta pilot balloon observatory which was temporarily located at Dera Ismail Khan was shifted to Fort Sandeman as it was considered that its location at the latter station would be more valuable to the R. A. F. and the forecaster. Night balloon ascents were begun at Gwador, Bahrein, Sharjah and Juhu.

18 pilot balloon observatories were inspected during the year. In order to participate in the All-India Exhibition of Arts and Industries held at Lahore, exhibits representing the activities of the department were collected. An officer and an observer from Agra went to Lahore to organise the "Meteorology" show-stall in the exhibition.

A manual of administrative instructions was compiled and copies distributed to pilot balloon observers. Rules for protecting Government buildings and other properties against fire were drawn up on the lines suggested in the 'Fire Rules' issued by Government. The increasing demands on the staff at pilot balloon observatories as a result of the development of aviation necessitated the active consideration of where and how one could economise in other work in order to make it possible for the increased work to be undertaken without extra staff. Local audit of the Agra office was carried out by auditors from the office of the Accountant General, United Provinces. A draft agreement with the Agra Electric Supply Co., Ltd., for supply of electrical energy to the Agra Observatory for a further period of 5 years from 1st April 1937 was received from the Company and its execution was under consideration. The Stores section of the office was reorganised and both the Laboratory and the General Stores amalgamated and placed under the control of a Stores and Supply Assistant.

The usual duties of a 1st Class Observatory and pilot balloon and seismic station were carried out. As usual, the technical data received from pilot balloon observatories were scrutinised and sounding balloon records regularly worked out. Manuscripts of upper air and seismic data for routine departmental publications were prepared. Afternoon normal wind frequency tables were worked out for all stations having 3 years' data or more up to the end of 1935. The compilation of these frequency tables for publication was taken in hand. Facilities were given as usual to Dr. K. C. Mehta of the Agra College in his investigations on the transport of spores for cereal rust. 16 candidates for pilot's B licence were trained and examined in Meteorology.

3,66,500 cubic feet of hydrogen were manufactured during the year.

The observatory continued to be a chief centre for upper air investigations and for manufacture of upper air instruments, such as the sounding balloon meteorograph. A large number of meteorological instruments was tested and calibrated. Sounding balloon ascents were made at Agra as usual. In addition, special sounding balloon ascents were

made at a number of other stations during the monsoon season. In all, the Agra office arranged for 178 soundings at different stations and 78 instruments were retrieved.

Various special problems of practical as well as theoretical interest to the department were tackled during the year; some of these have already been mentioned under the Chief Features. In addition, rubber sheetings and balloons of various kinds obtained from several foreign countries were tested to find out which of them was most suitable for upper air work in India. A fuse-and-spring-contact arrangement was devised by means of which one of the two bulbs in the lamp for the night pilot balloon is switched on about 10 minutes after the release of the balloon. By this device the intensity of light can be made greater after 10 minutes compared with the intensity that is obtainable if both the bulbs are alight from the very beginning of the flight. A special meteorograph of the Dines' type, but fitted with a spring-controlled and exhausted aneroid instead of the usual type of aneroid, was made and tested to see if this type had any special advantage. Tests were made with the silicon-caustic-soda hydrogen generator of French manufacture to find out if it could be advantageously used at distant pilot balloon stations. Experiments were carried out to develop a suitable inert cell for night balloon ascents.

Colaba and Alibag Observatories.—These observatories which form the departmental centre for geophysical studies carried on, as usual, the routine meteorological, seismological, magnetic and atmospheric electricity work. The Colaba Observatory also received regular rhythmic time signals from Bordeaux or Rugby for rating the standard clocks and maintained the time supply service for the Port of Bombay. The time ball at the Prince's Dock tower was dropped regularly at 8-30 A.M. daily. The Colaba Observatory also continued to stock the Royal Indian Navy chronometers and watches for maintenance and rating, the average number of instruments for daily rating being 71.

The work of scrutinising and collecting seismological observations made at the departmental seismic stations was continued. A few photostat copies of Colaba seismograms were sent on request to foreign seismological and geophysical institutions. 30 shocks of moderate and 40 of great intensity were recorded by the seismographs at the observatory. The total number of shocks recorded with origin in India and neighbourhood was 28.

At the Alibag Observatory continuous records of the various magnetic elements were obtained and observations of absolute values of these elements were made as usual. Data regarding the magnetic character of days and the daily ranges of variation of magnetic elements were supplied regularly to the Royal Meteorological Institute, De Bilt, the Solar Physics Observatory, Kodaikanal and the Physics Department of the Allahabad University. Days of the years 1883 to 1894 which had already been classified for their magnetic character according to local time were reclassified, taking them as Greenwich days but retaining the old grades of classification. The Colaba data, thus reclassified,

were sent to the Royal Netherlands Meteorological Institute, De Bilt, Holland. Two magnetic storms of moderate and four of great intensity were recorded by the magnetographs at the Alibag Observatory. Information about the occurrence was supplied to the Telegraph Department, Bombay immediately after it was known that a magnetic storm was in progress.

Registration and measurements of the atmospheric potential gradient were carried on regularly at Alibag and Colaba. Meteorological observations with self-recording and eye-reading instruments were also carried on as usual both at Colaba and Alibag.

The Gestetnered Daily Weather Report giving the summary of the principal features of weather over western India based on material telephoned from the Poona Meteorological Office was issued regularly during the period 1st May to 30th November. The collection of weather logs from ships calling at the Bombay Port and the standardisation of their barometers were carried on as usual.

Pilot balloon work was carried on at the Juhu aerodrome. 14 meteor reports were supplied from Juhu to the Officer Commanding, 14th Heavy Battery, R. A., Colaba.

Copies of the observatory volume for 1935 were distributed and proofs of the volume for 1936 sent to the Press.

A number of enquiries regarding magnetic, seismic, astronomical and meteorological information were answered.

Some items of investigational work in geophysics, terrestrial magnetism and atmospheric electricity have already been mentioned in the opening chapter. In addition, a study was commenced of the Hindu-Kush earthquake of November 1937 and the Khandwa earthquake of March 1938; progress was made in the study of day-to-day variability of the horizontal force of the earth's magnetic field at different places and a study was begun of magnetic disturbances associated with radio fade-outs. A research student working at the observatory was awarded the M.Sc. degree of the Bombay University for a thesis entitled "Studies in Atmospheric Visibility". Regular observations on the counting of condensation nuclei in the atmosphere were commenced by research students. A monograph on "The general circulation of the Atmosphere over India and its neighbourhood" by the Meteorologist-in-charge in collaboration with Mr. Ramakrishnan of the Poona Office was completed.

The Meteorologist was elected President of the Physics and Mathematics Section of the 26th Session of the Indian Science Congress to be held at Lahore during January 1939.

Alipore Observatory and Meteorological Office, Calcutta.—The principal functions of this office *viz.*, (1) storm warning for the Bay of Bengal, (2) heavy rainfall warning for northeast India and neighbouring areas (3) squall warning for Bengal and (4) the issue of weather reports and forecasts to the public and aviators were carried on as usual. On the separation of Burma and consequent formation of an independent meteorological service there, the Calcutta Office was relieved of administrative control over the surface observatories in Burma from 1st April

1937 and of technical control over these observatories as well as of responsibilities for issue of weather reports and forecasts to aviators and to the public in respect of the Burma area from 1st July 1937. One item of work *viz.*, the issue of storm warnings to shipping in the Burman waters and to Burman ports continues still to be done by the Calcutta Office on behalf of the Burma Meteorological Department.

The Calcutta Daily Weather Report continued to be published throughout the year. A daily weather report for Burma containing a general summary of weather conditions, divisional reports and forecasts as also tabular statement of data was issued by the Calcutta Office during the period 15th May 1937 to 30th June 1937 and delivered to the Associated Press for transmission to Rangoon. The regional weather telegraphic summary for northeast India which was introduced last year continued to be issued from this office. The forecast for Burma areas was included in the telegraphic summary only up to 30th June 1937. A daily weather bulletin briefly summarising the weather conditions at the head of the Bay and over deltaic Bengal was issued to the All-India Radio for broadcasting through their Calcutta Station for the special benefit of ocean and river craft. The supply of a daily weather bulletin and seismic information to the Sun Advertising Co., for display in their electric newspaper at the Esplande, Calcutta which had been temporarily suspended, was resumed on the 20th December 1937.

The departmental officers' Conference was held in Calcutta during the last week of December 1937.

The Calcutta Office was responsible for the administration of 77 surface observatories (including the observatories maintained from private funds at Jamshedpur, Dhanbad, Lumding and Cooch Behar) besides the Alipore observatory itself. 43 departmental observatories and 2 observatories maintained from private funds were inspected during the year. A gazetted officer from Calcutta visited Agartala at the request of the Tripura State to select a site for the proposed meteorological observatory at that station. A second class observatory was started at Aijal while the fourth class observatories at Salona (Messa) and Goalundo were closed down. The Dibrugarh observatory was raised to second class. The weekly weather telegrams from Pabna and Brahmanbaria were discontinued.

The meteorological and seismological observations as well as the time-determination and time-signalling work were carried on at the Alipore Observatory as in the previous years. The work of testing meteorological instruments of the Mathematical Instruments Office, of the Chemical Examiner to the Government of Bengal, and of ships' captains was done as usual. A number of Sub-Assistant Surgeons were given training in temperature and rainfall observations at the request of the Assistant Director, Public Health, Malaria Research, Bengal. Mr. G. R. Rendall, deputed by the Director, Seismic Station, Rangoon University was given necessary training in seismological work. At the request of the Divisional Engineer, Telegraphs, Calcutta Division, Mr. Nursang Sardar who was to record observations in the Rangbuk Glacier in Tibet during October and November was

trained in recording meteorological observations. A clerk deputed by the Tripura State was similarly trained. About 250 Science Teachers of different schools in Bengal deputed by the Calcutta University were given facilities to study the working of the instruments at the observatory.

It is gratifying to note the increased interest taken by the public in the activities of the observatory. Visitors came in much larger numbers than in the previous years; there was also an increasing demand for meteorological and other information.

Pilot balloon observations continued to be made at Alipore pending construction of necessary buildings at Dum Dum. Arrangements were however being considered towards the end of the year to shift the observatory to Dum Dum. The supply of current weather reports was carried on partly from Alipore and partly from Dum Dum. The Professional Assistant was stationed at Dum Dum in order to supply current weather reports from the aerodrome and to meet the pilots. From 1st March 1938 he also took over the responsibility of receiving and exhibiting Newsmet and other weather reports during his hours of attendance.

8 sounding balloons were let off from Alipore in July for studying the structure of monsoon depressions.

At the request of Mr. Kemp of the Indian Air Survey and Transport Ltd., forecasts of weather conditions over Chittagong-Akyab, Chittagong-Dacca and Dacca-Sylhet regions were supplied daily for a week from 14th March, 1938. The reception by the Calcutta office of the broadcasts from Rangoon and Karachi led to an improvement in the Calcutta charts. Also, with the commencement of the Rangoon synoptic issues, the daily telegrams containing observations of Akyab, Victoria Point and Rangoon, which were being sent from Calcutta to Bangkok, were discontinued with effect from the last week of February after consultation with the Siamese Government.

Meteorological Office, Karachi.—This office continued to supply weather reports and forecasts for the main air route from Bahrein to Allahabad, for the feeder route from Karachi to Lahore and for the Karachi-Ahmedabad Section of the Karachi-Madras route. It also supplied route forecasts to aircraft flying over other routes in its area of responsibility. The Bhopal-Delhi section of the Bombay-Delhi air service was an addition made during the year to the routes for which regular supply of weather reports had to be made by this office. On the Iraq Meteorological Service taking over the forecasting duty for the region west of Sharjah/Jask from 1st March 1938, the Karachi Office was relieved, with effect from that date, of the responsibility for forecasting for the Sharjah/Jask-Bahrein section of the main air route.

The Empire Air Mail Development Scheme entailed considerable increase of work for the office. New current weather stations were started at Gwalior and Raj Samand and the climatological data collected at these stations were summarised for the benefit of Imperial Airways. Early morning current weather work was introduced at stations in the Persian Gulf and schedules of supply of MET and PILOT reports by wireless on the Persian Gulf route were revised to fit in with the new

time tables of the Empire Air Mail Scheme. The arrangements for the Karachi-Lahore route had also to be revised to fit in with the new time tables.

Lamps for measurement of visibility at night were installed at Drigh Road, Gwador and Bahrein, and electrical anemometers were installed at Jodhpur, Drigh Road and New Delhi.

The K. L. M. Service was triplicated from 1st October 1937. Instructions were issued to observatories at Bushire and Jask for supplying special weather observations on request to that service. The duty hours of the observers at Gwador and Sharjah were also extended as the local wireless station began to keep watch for the K. L. M. planes flying between Karachi and Bushire. Special arrangements were made for reports of bad visibility at the aerodrome to be given by an observer at Gwador on flying days of the Imperial Airways. Instructions for reporting current weather were given to the flood-light operators at Hyderabad and Utterlai. Arrangements were made for the issue of certain current weather messages from Cawnpore and Multan.

Arrangements were completed for the starting of surface observatories at the aerodromes at New Delhi and Jodhpur. The auxiliary centre at New Delhi took over all work in connection with the reception of weather reports and their exhibition at the Delhi aerodrome.

The observatory at Drigh Road continued its functions as a first class observatory and auxiliary centre and served as an agency for the reception of requisitions for weather reports and forecasts from, and distribution of weather reports to, pilots. An observer from the Government Agricultural farm at Sakrand as also the aerodrome clerk at Multan were trained in observational work.

The supply of observational data to the R. A. F. Meteorological Officers at Hinaidi, Peshawar and Heliopolis continued as usual. Special weather reports and forecasts were supplied to special flights of R. A. F. planes and flying boat squadrons. The number of weather reports and forecasts issued to the R. A. F. numbered 230. There were also 3,907 sets of routine weather data supplied to the R. A. F. from the Drigh Road Observatory, while 1,425 sets of observations were received from R. A. F. personnel. The office continued to receive from the R. A. F. records of the aeroplane temperatures as in the past. A number of enquiries for meteorological information were answered both by the Karachi Office and by the Drigh Road Observatory. The office continued to co-operate with the Locust Research Entomologist; he was supplied with meteorological information direct from the Mekran observatories as and when required and some instruments were loaned to him for use at his desert observatories.

Broadcasts of synoptic data of selected stations in northwest India and Iran began to be issued from the Karachi short-wave wireless station from 1st August 1937 from which date similar broadcasts from Calcutta were also picked up by Karachi. These broadcasts were of considerable help and resulted in an extension of the Karachi weather charts.

The Karachi Daily Weather Report continued during the year, the number of subscribers during the year being 29. The telegraphic

regional weather summary for northwest India introduced last year was issued daily.

Pilots of the main air lines frequently visited the office to discuss weather conditions personally with the officers. Weather logs were received from the pilots of the various air services regularly. 8 pilots were trained and 7 examined for Pilot's B licence in elementary Meteorology.

The Karachi Office administered 89 observatories including current weather observatories in its area of responsibility. Of these, 38 observatories were inspected during the year including a number of observatories in the Persian Gulf. A new 2nd class observatory was opened at the Consulate at Bunder Abbas and arrangements were completed to open a 2nd class observatory at Leiah.

The office continued to be housed in rented premises at Karachi. Considerable progress having been made in the building programme at Drigh Road it is expected that it will be possible to transfer the office to its permanent home at Drigh Road towards the end of 1938.

Kodaikanal Observatory.—The solar and astronomical researches carried on during the calendar year 1937 will be found summarised in the Annual Report of the Kodaikanal Observatory for that year. The routine work of the observatory was carried on as in past years, and co-operation extended to the other observatories under the auspices of the International Astronomical Union. A report on the prominences and the general work of the observatory for the year 1937 was sent to the Royal Astronomical Society. The usual statements of character figures of solar activity, of bright eruptions and of spectrohelioscopic observations were sent to scientists and institutions interested, like the Meudon Observatory, the Mount Wilson Observatory and Prof. Brunner of Zurich. A statement of metallic prominences was sent to Prof. Abetti, Arcetri, and some calcium flocculi spectroheliograms to the Director, Solar Physics Observatory, Cambridge. With a view to make photometric measures of the intensities of bright Hα eruptions relative to the photospheric background, a step wedge was designed, calibrated and mounted on the spectrohelioscope. A few representative Hα spectroheliograms taken at Kodaikanal were sent to Prof. Brunner of Zurich for fixing standards of character figures of solar activity. A Kölhörster Cosmic Ray electrometer was set up and continuous records of cosmic ray were taken with it for about a fortnight. The data are being studied. Other important items of investigational work at the observatory have been mentioned under the Chief Features.

Meteorological Office, Quetta, temporarily located at Karachi.—The office remained under the charge of an officer deputed from the India Meteorological Department but paid for by the Royal Air Force and continued to be located temporarily in the premises of the Karachi Meteorological Office.

As in previous years, a general inference and forecast of weather over Sind, Baluchistan and the Punjab together with a local forecast for Karachi was supplied every night (except on Saturdays) to the Aircraft Depot and 31 A. C. Squadron, R. A. F., Drigh Road and G. O. C. Western Command, Karachi. The inference and forecast was supplied

by W/T every morning to the detachment at Fort Sandeman and also to Quetta whenever a detachment was temporarily stationed there. In addition to the routine forecasts, 166 route forecasts, 85 special regional weather forecasts, 17 special upper wind forecasts and 16 local forecasts for night flying were issued. Special warnings of adverse weather were also issued on 16 occasions. 33 'Meteor' reports were issued on request in connection with artillery practice. Observations of upper air temperatures and humidities were taken by R. A. F. planes on 121 occasions at Drigh Road and on 17 occasions at Fort Sandeman. The results of the ascents made at Drigh Road were telegraphed to Poona and published in the Indian Daily Weather Report. On special request, the Aircraft Depot and 31 A. C. Squadron specially arranged to make aeroplane meteorological flights at different hours of the day on the International Days in April, August and December, 1937 in order to collect data for studying the diurnal characteristics of the lower atmosphere over Karachi. It may be mentioned, as a matter of interest, that in some of the meteorological flights made in December, 1937 ice accretion was reported at heights of 13,000 to 15,000 feet. Some trials were made in sending up different types of meteorographs on aeroplanes and a few records obtained.

The meteorologist visited the Aircraft Depot and 31 A. C. Squadron frequently to keep himself in touch with their requirements and discussed questions relating to weather, weather forecasts and aeroplane meteorological flights. Three lectures were delivered, on request, at the Aircraft Depot on meteorological subjects of interest to aviators. At the request of the Officer Commanding, a Stevenson screen and a set of four thermometers were installed at the Aircraft Depot. In addition to items of investigation mentioned under the Chief Features, a study was undertaken of the data of meteorological aeroplane flights made at different hours of the day on some days in 1928, 1929, 1930 and 1937.

Meteorological Office, Peshawar.—This office which functions as a forecast office for the R. A. F. and also as a first class observatory and pilot balloon observatory, continued under the charge of a R. A. F. Meteorological Officer, who is under the technical control of the Director General of Observatories. Routine reports and forecasts were issued at 8 hrs. daily by R. A. F. W/T to all Units stationed in the Punjab, the N.-W. F. Province and Waziristan. In addition, a detailed report and forecast was made available daily to No. 1 (Indian) Group, R. A. F., No. 20 (A. C.) Squadron, R. A. F., Peshawar District and Brigade Headquarters, Government House and the Officer Commanding, B. M. H., Peshawar. 249 route forecasts were issued to R. A. F. Units on request and special forecasts for night flying were issued as required. Artillery Units were supplied with Meteor reports on request. Many enquiries concerning weather and instrumental data for Peshawar were answered, notably from Peshawar hospitals and colleges. Rainfall warnings were issued to the Executive Officer, Canals Division, Peshawar whenever necessary. R. A. F. Units at Kohat, Peshawar and Risalpur made 354 observations of upper air temperatures and humidities by aeroplane ascents. The results were telegraphed to Poona and published in the Indian Daily Weather Report. Arrangements were made for similar observations to be made during

certain periods of the year at Ambala and Hyderabad (Sind). 13 meteorological flights were made at Ambala between January to March 1938. Two R. A. F. pilots attended the office to study meteorology for the 2nd Class Air Navigator's Licence Examination. As a result of the recommendations of the R. A. F. Meteorologists, the Headquarters R. A. F. arranged that all meteorological messages sent through R. A. F. W/T should be classed as 'Important', unless otherwise marked, as an experimental measure. The morning weather map at Peshawar was improved by the addition of observations from Skardu, Srinagar and Gilgit. The Meteorological Officer completed his study of ionisation records at the Kew Observatory.

Other Observatories.—The numbers of observatories of various classes are shown in the table below, with the corresponding figures at the end of the previous year. The reduction in the total number of observatories is due to the separation of Burma.

Class.	On 31st March 1938.	On 31st March 1937.
I Class	14	14
II Class	192	173
III Class	47	87
IV Class	18	22
V Class	24	24
Non-Instrumental	16	16
* Total	311	336
Non-departmental	61	62

* This total includes the non-departmental observatories whose number is shown separately in the next row.

The records of the non-departmental observatories were scrutinised by this department and in most cases utilised in the daily weather reports and other departmental publications. The importance of these observatories need hardly be emphasised and the co-operation of the Indian States and other public bodies, who maintained them for the furtherance of the study of Indian Meteorology, is much appreciated. Among these may be mentioned the Kingdom of Nepal and the States of Hyderabad, Kashmir, Mysore, Baroda, Bhopal, Travancore, Bahawalpur, Bikaner, Jodhpur, Jaipur, Udaipur, Cooch Behar, Jhalawar, Nawanagar, Ichalkaranji, Kotah and Miraj, the municipalities of Ahmedabad, Ootacamund, Coonoor, Murree and Mussooree and the Agricultural Departments of Bombay, Sind and the Punjab.

VI. RAINFALL REGISTRATION.

The rainfall data collected by the provincial rainfall organisations, for which the Director General of Observatories is the consulting

authority, are published in the provincial rainfall tables, which are collected and issued in a single volume for the whole of India by this department. The number of stations included in the organisation in the different provinces and the number inspected during the year, together with corresponding figures for the previous year, are given in the following table. On the whole the work of rainfall registration was carried out satisfactorily throughout India.

Rainfall Registration during 1937-38.

No.	Province.	Number of raingauges at the end of			No. of raingauges inspected.			Remarks.
		1937-38.	1936-37.	Change.	1937-38.	1936-37.	Change.	
1	Assam. . . .	127	127	0	109	84	+25	
2	Bengal (*a*) . . .	232	236	—4	188	201	—13	
3	Orissa . . .	74	74	0	60	71	—11	
4	Bihar . . .	239	239	0	207	216	—9	
5	United Provinces . .	274	273	+1	261	255	+6	
6	Punjab . . .	196	196	0	175	170	+5	
7	Jammu and Kashmir .	30	30	0	11	7	+4	
8	North-West Frontier Province.	31	31	0	29	30	—1	
9	Baluchistan. . .	78	78	0	75	75	0	
10	Sind . . .	67	61	+6	44	56	—12	
11	Rajputana . . .	188	188	0	163	160	+3	
12	Bombay . . .	200	198	+2	174	179	—5	
13	States in the Bombay Presidency.	79	79	0	47	47	0	
14	Central India . .	125	123	+2	107	100	+7	
15	Central Provinces .	162	162	0	160	159	+1	
16	Berar	42	42	0	42	42	0	
17	Eastern States (*a*) .	61	47	+14	60	46	+14	
18	Hyderabad . . .	60	58	+2	60	0	+60	
19	Mysore . . .	76	75	+1	76	75	+1	
20	Coorg . . .	21	21	0	21	21	0	
21	Madras . . .	492	488	+4	447	465	—18	

(*a*) 5 raingauges were transferred from under Bengal to under Eastern States.

Heavy Rainfall Reports.—Heavy rainfall is sometimes so very local that small unrepresented areas can have as much as 10 inches without the present net-work of daily reporting stations conveying the least suggestion of the local deluge. To obtain reports of such local heavy rain promptly for the daily weather report, it was arranged 17 years ago that observers at all raingauge stations at district headquarters in British India as well as in Indian States should telegraph to forecasting centres falls of 5 inches or more. Nearly 300 such telegrams were received at Poona during 1937-38.

Snowfall Registration.—Information about the distribution and the time of occurrence of snowfall in the Himalayas and the Afghan mountain areas was on the whole tolerably complete, and the thanks of the department are due to the various officers who collected and forwarded the reports.

VII. CONCLUDING REMARKS.

The Meteorological Department owes a large part of its usefulness to the sympathetic assistance it receives from other departments. Officers of various Government departments help the meteorological work as honorary superintendents of observatories or in other capacities. Special mention may be made of the assistance rendered by them in the systematic collection of hail reports from the rain-gauge stations under them. The India Meteorological Department is greatly indebted to the Imperial Council of Agricultural Research for inaugurating work in Agricultural Meteorology. The department is also very grateful to the Principal of the Agricultural College, Poona, for the facilities given for experimental work at the College Farm. The Posts and Telegraphs Department assists this department in the rapid transmission of meteorological information particularly in connection with the warning services.

Weekly telegrams are received from April to October from the Director, Royal Alfred Observatory, Muritius. These telegrams give valuable information of the weather conditions in the Indian Ocean and the department is indebted to this observatory for the punctual transmission of the information.

The department is greatly indebted for important information on meteorological conditions prevailing before and during the southwest monsoon to the Director General, Physical Department, Cairo; the Directors of the Observatories at Buenos Ayres and Santiago; the Astronomer Royal, Cape Town; the Director, British East African Meteorological Service, Nairobi; the Port Officer, Seychelles; the Commonwealth Meteorologist, Melbourne; Chief Meteorologist, Salisbury, Southern Rhodesia; Chief of the Weather Bureau, Washington; the Director, Koninklijk Magnetisch und Meteorologisch Observatorium, Batavia, who also arranges kindly for the daily weather telegrams from Sabang in Sumatra.

Thanks are due to the various ships which wirelessed or posted weather messages (including pilot balloon messages) and to the Marine Superintendents of the British India, Peninsular and Oriental, Scindia, Asiatic, Bombay and Persia Steam Navigation Companies and the Burma Oil, the Anglo-Iranian Oil and Indo-Burma Petroleum Companies for continuing the arrangement under which many captains of their fleets send weather logs to this department; to the various ships' officers who sent their marine weather logs direct to this department, and to the Principal Officer, Mercantile Marine Department for arranging meetings at his office between an officer of this department and ships' captains.

Thanks are also due to the Superintendent of the Colombo Observatory for the most useful help he has rendered from time to time in connection with storm warning work and for the useful data of Ceylon stations supplied to this department.

C. W. B. NORMAND,
Director General of Observatories.

POONA 5,
The 15th July 1938.

APPENDIX A.

The Staff of the India Meteorological Department as it stood on 31st March 1938.

METEOROLOGICAL OFFICE, POONA.

Director-General of Observatories.

C. W. B. Normand, C.I.E., M.A., D.Sc. (Edin.).

General Section.

Meteorologist	A. K. Roy, B.Sc. (Cal.), B.A. (Oxon).
Assistant Meteorologist	B. N. Sreenivasaiah, M.Sc. (Cal.).
Superintendent	C. P. Venkataramier, M.A. (Madras).
Assistants	5
Stenographers and Steno-Typists	5
Cashier	1
Senior Clerks or Observers	2
Clerks and typists	12

Weather Section.

Meteorologist	S. N. Sen, M.Sc. (Cal. and London), Ph.D. (London).
Assistant Meteorologists	H. R. Puri, M.Sc. (Punjab) (offg.).
	P. K. Sen-Gupta, D.Sc. (Allahabad) (offg.).
Assistants	3
Clerks and tabulators	15
Draftsmen	9

Observatories Section.

Assistant Meteorologist	Barkat Ali, B.A., M.Sc. (Punjab).
Assistants	2
Inspector of Observatories	1
Clerks	2
Current Weather Observers	8 (at outstations—including one at Juhu).

Marine Section.

Meteorologist	K. J. Kabraji, B.A. (Hons.), B.Sc. (Bombay), M.Sc., Ph.D. (London).
Assistant	1
Clerk	1

Instruments Section.

Meteorologist	J. M. Sil, B.A. (Cal.), B.Sc. (Engg.) (Boston Tech.).
Assistant Meteorologist	K. Das, M.Sc. (Punjab), Ph.D. (Lond.)
Assistants	2
Clerks	5
Draftsman	1
Senior Observers	3
Junior Observer	1
Senior Store-keeper	1
Junior Store-keeper	1
Chief Mechanic	1
Mechanics	3
Carpenter	1

Upper Air Section.

Meteorologist	N. K. Sur, D.Sc. (Allahabad).
Assistant Meteorologist	R. Ananthakrishnan, M.A., D.Sc. (Madras) (offg.).
Assistant	1
Clerks	2
Senior Observer	1
Junior Observers	4

Statistical Section and Library.

Meteorologist	S. R. Savur, M.A. (Madras), Ph.D. (Lond.).
Assistant Meteorologist	V. Doraiswami Iyer, B.A. (Madras).
Assistants	3
Librarian	1
Clerks	15
Draftsmen	3

Officer on special duty.

Meteorologist	S. K. Banerji, M.Sc., D.Sc. (Cal.).

Agricultural Meteorology Section.

Agricultural Meteorologist	L. A. Ramdas, M.A., Ph.D. (Cal.)
Assistant Meteorologist	A. K. Mallik, M.Sc., B.Sc. (Ag.) (Allahabad), Assoc.I.A.R.I. (Temporary).
Meteorological Assistant	1
Senior Observers	2
Junior Observers	3
Typist	1

Upper Air Observatory, Agra.

Meteorologist-in-charge	G. Chatterjee, M.Sc. (Cal.).
Meteorologist	S. Basu, M.Sc. (Allahabad).
Assistant Meteorologists	S. P. Venkiteshwaran, B.A. (Hons.) (Madras). L. S. Mathur, M.Sc., D.Phil. (Allahabad) (offg.). N. P. Chatterjee, M.Sc. (Cal.) (Temporary).
Superintendent	Babu Ram Samnol, B.A. (Punjab).
Mechanical Assistant	Chain Sukh.
Chief Observer	1
Chief Computer	1
Foreman	1
Inspector of Observatories	1
Stores and Supply Assistant	1
Clerks or Observers	41 (at Agra).
Clerks or Observers	73 (at outstations).
Mechanics	11
Enginemen	3

Colaba and Alibag Observatories, Bombay.

Meteorologist	K. R. Ramanathan, M.A., D.Sc. (Mad.).

At Colaba.

Head Clerk	D. L. Chaudhuri, M.Sc. (Cal.).
First Assistant	1
Observers	6
Cashier	1
Marine Clerk	1
Typist and Stenographer	1

At Alibag.

Observers	2

Alipore Observatory and Meteorological Office, Calcutta.

Meteorologist	S. K. Pramanik, M.Sc. (Lucknow). Ph.D. (Lond.), D.I.C.
Assistant Meteorologists	B. K. Roy, M.Sc. (Cal.) S. Mal. M.Sc. (Benares), Ph.D. (Lond.), D.I.C., F.R.Met.Soc. C. Ramaswamy, M.A. (Hons.).
Superintendent	T. N. Mitra, B.A., B.L.
Chief Observer	R. Baksi, M.Sc. (offg.).
Meteorological Assistant at Allahabad	1 (on Poona Establishment, posted at auxiliary centre).
Inspector of Observatories	1
Clerks (Upper Division)	6

Alipore Observatory and Meteorological Office Calcutta—contd.

Stenographer	1
Senior Observer	1
Clerks (Lower Division)	25
Clerks and Typists (Routine Division)	5 (including two posts of teletypists).
Current Weather Observers	2 (at outstations).
Printer (Press staff)	1

Dum Dum Branch.

Professional Assistant	B. B. Roy, M.Sc. (offg.).
Senior Observer	1
Junior Observers	3

Meteorological Office, Karachi.

Meteorologist	V. V. Sohoni, B.A. (Hons.), M.Sc. (Bombay).
Assistant Meteorologists	B. N. Desai, B.A. (Hons.), LL.B., M.Sc. (Bombay), Ph.D. (Edin.), F.R.S.E. S. L. Malurkar, B.Sc. (Mysore), M.Sc. (Cantab.)
Professional Assistant	S. N. Roy Chowdhury, M.Sc. (Cal.) (offg.).
Meteorological Assistant at New Delhi	1 } On Poona Establishment, posted at
Meteorological Assistant at Jodhpur	1 } auxiliary centres.
Chief Observer	1
Head Clerk	1
Inspector of Observatories	1
Steno-typist	1
Senior Clerks or Observers	5
Clerks or Observers	16
Junior Clerks or Observers	2
Observers	7 (at outstations).
Clerk (temporary)	1

Solar Physics Observatory, Kodaikanal.

Director	A. L. Narayan, M.A., D.Sc. (Madras), F.I.P.
Assistant Director	A. K. Das, M.Sc. (Cal.), D.Sc. (Paris), F.R.A.S.
Assistants	3
Recorders	4
Mechanic	1
Book-binder	1

Meteorological Office, No. 3 (Indian) Wing, R. A. F., Quetta, temporarily transferred to Karachi.

Meteorologist	P. R. Krishna Rao, B.Sc. (Mysore) (temporary).
Senior Clerk	1
Junior Clerk	1

Meteorological Office, No. 1 (Indian) Group Headquarters, R. A. F., Peshawar.

Meteorological Officer (R. A. F.) . .	Fl. Lt. L. H. Starr.
Senior Clerk	1
Junior Clerks and Observers . .	4

Lahore Observatory.

Chief Observer	1
Clerks or Observers	3

Madras Observatory.

Assistant-in-charge	1
Senior Observer	1
Junior Observers	2

Pilot Balloon Observatory, Juhu.

Professional Assistant . . .	1
Senior Observer	1
Junior Observers	2

Officers on leave.

T. Royds, D.Sc. (London), F.R.A.S. (Leave on average pay for four months and eighteen days combined with leave on half average pay for 20 months and 12 days, preparatory to retirement from 12th March 1937).

Officers on Foreign Service.

S. C. Roy, M.Sc. (Cal.), D.Sc. (London). Meteorologist.

S. S. Lal, M.Sc. (Lucknow and London), D.I.C. (London), A.Inst.P., F.R.Met. Soc. Asst. Meteorologist.

S. K. Das. M.Sc. (Dacca and London), D.I.C. (London) F.R.Met,Soc. (London) Asst. Meteorologist.

APPENDIX B.

PUBLICATIONS.

The following departmental publications were issued or sent to press during the year:—

I.—*Periodical.*

1. Daily Weather Reports:—
   (i) Indian Daily Weather Report (to date).
   (ii) Calcutta Daily Weather Report (to date).
   (iii) Karachi Daily Weather Report (to date).
2. Weekly Weather Report (to date).
3. India Weather Review, Monthly Weather Report (to date).
4. India Weather Review, Annual Summary, 1936, in five parts:—
   (i) Introduction.
   (ii) Part A.—Summary of Weather with Tables.
   (iii) Part B.—Snowfall.
   (iv) Part C.—Storms and Depressions.
   (v) Part D.—Seismic Records.
5. Daily Rainfall of India, 1935.
6. Monthly Rainfall of India, 1935.
7. Upper Air Data, 1936, in 2 parts:—
   (i) Part A.—Monthly Means of Pilot Balloon Data.
   (ii) Part B.—Sounding Balloon and Aeroplane Data.
8. Seasonal Memoranda:—
   (i) Memorandum on the probable character of the weather in northwest India in January, February and March 1938.
   (ii) Statement of the rainfall and snowfall of northwest India in January, February and March 1937.
   (iii) Memorandum regarding the probable amount of monsoon rainfall in 1937.
   (iv) Memorandum on the rainfall of June and July and the probable amount during August and September 1937.
   (v) Statement of actual rainfall in the monsoon season, June to September 1937.
9. Magnetic Meteorological and Seismographic Observations made at the Government Observatories, Bombay and Alibag, in the year 1935.
10. Report on the Administration of the Meteorological Department of the Government of India in 1936-37.
11. Report of the Kodaikanal Observatory for the year 1937.

II.—*Occasional.*

1. Memoirs of the India Meteorological Department:—
   Vol. XXVI—
   Part VIII—Measurements of the radiation from the sun and the sky at Poona in 1935, by P. K. Raman.
   Part IX—Discussion of results of soundings at Jhikargacha in Bengal during April and May 1929, by G. Chatterjee and N. K. Sur.

2. Scientific Notes:—

Vol. VII—

No. 74—The rainfall in the Indian Peninsula associated with cyclonic storms from the Bay of Bengal during the post-monsoon and early winter seasons, by K. P. Ramakrishnan.

No. 75—Squalls at Karachi, by P. R. Krishna Rao.

No. 76—Average intensity of rainfall on a rainy day in India, by V. Doraiswamy Iyer and Kasturinath Sobti.

No. 77—Distribution of heavy rainfall over India, by V. Doraiswamy Iyer and M. Zafar.

No. 78—Temperatures and humidities up to 3 km. over Karachi, by P. R. Krishna Rao and K. L. Bhatia.

3. Kodaikanal Observatory Bulletin:—

CXII—Summary of prominence observations for the first half of the year 1936.

CXIII—Summary of prominence observations for the second half of the year 1936.

The following papers, or notes, were contributed to extra-departmental journals—

Ananthakrishnan, R.—

Effect of temperature on the Raman spectrum of liquid CCl_4, Proc. Ind. Acad. Sci., Vol. 7A, 1938, pp. 196—207.

Chiplonkar, M. W. (Research Student)—

Measurement of air-earth currents passing through elevated points during electrically disturbed weather at Colaba, Bombay, J. Univ., Bombay, Vol. 6, 1937, pp. 9—17.

Desai, B. N.—(D. L. Barve, Y. H. Paranjpe and—)

Mutual coagulation of colloidal solutions, J. Univ. Bombay, Vol. 6, 1937, pp. 50—56.

Katti, M. S. (Research Student)—

Soil moisture in relation to moisture in the surface layers of the atmosphere during the clear season, J. Univ., Bombay, Vol. 6, 1937, pp. 3—8.

Mallik, A. K.—(R. B. Deshpande and—)

Studies in Indian oil-seeds, VI, some correlations between oil-content and other characters in the Pusa linseed hybrids, Ind. J. Agric. Sci., Vol. 7, 1937, pp. 841—848.

Malurkar, S. L.—

Study of instability in layers of fluids when the lower surface is heated, Gerl. Beitr. Geophys., Vol. 51, 1937, pp. 270—277.

Normand, C. W. B.—

Energy realisable in the atmosphere, Q. J. Roy, Met. Soc., Vol. 63, 1937, pp. 321—322.

Energy realisable in the atmosphere (second note), Q. J. Roy, Met. Soc., Vol. 63, 1937, pp. 494—497.

The weather of India (Repr. from an Outline of the Field Sciences of India), Calcutta, Ind. Sci. Congr. Ass., 1937, p. 16.

The sources of energy of storms (Pres. address Sec. Math. Phys., 25th Ind. Sci. Congr., Calcutta, 1938). Calcutta, Ind. Sci. Congr. Ass., p. 19.

Normand, C. W. B.—*contd.*

On instability from water vapour, Q. J. Roy, Met. Soc., Vol. 64, 1938, pp. 47—69.

Kinetic energy liberated in an unstable layer, Q. J. Roy, Met. Soc. Vol. 64, 1938, pp. 71—74.

Ramanathan, K. R.—

Effcet of near lightning discharges on a magnetometer, Nature, Vol. 140, 1937, p. 587.

Two recent earthquakes in northwest India, Curr. Sci., Vol. 6, 1937, pp. 275—276.

Ramdas, L. A.—

Crop protection from the effects of weather, Proc., 2nd Meeting of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry, India, December 1937, p. 11.

The variation with height of the water vapour content of the air layers near the ground at Poona, Bioklim. Beibl., 1938, pp. 30—34.

The dust-free or dark layer surrounding a hot body in relation to the convective movements in its neighbourhood, J. Univ. Bombay, Vol. 6, 1937, pp. 18—22.

—— and R. J. Kalamkar—

Statistical investigations on crop-weather relationships in India, Sankhya, Vol. 3, 1938, pp. 285—290.

—— and A. K. Mallik—

The exchange of moisture between air layers near the ground and substances like soils, plant leaves, seeds, etc., exposed to the atmosphere, Curr. Sci., Vol. 6, 1938, pp. 452—453.

—— (Narasimhan, M. and—)

Agricultural meteorology: the prediction of the minimum temperature on clear days at selected stations in India, Ind. J. Agric. Sci., Vol. 7, 1937, pp. 745—761.

—— and P. S. Vaidyanathan—

Studies on the spreading of certain substance on a clean surface of water, Part I, Proc. Ind. Acad. Sci., Vol. 7A, 1938, pp. 186—195.

Royds, T.—

Solar wave-length displacements observed at the Japan eclipse of 1936, June 19th, Mon. Not. Roy. Astr. Soc., Vol. 97, 1937, pp. 692—695.

Savur, S. R.—

A general coefficient of statistical relationship, Curr. Sci., Vol. 6, 1937, pp. 18—19.

The use of the median in tests of significance, Proc. Ind. Acad. Sci., Vol. 5A, 1937, pp. 564—576.

The replication of an experiment, Part I, Identical samples from a binomial population, Proc. Ind. Acad. Sci., Vol. 6A, 1937, pp. 174—178.

Evaluation of Ip (n—r, r+1), Proc. Ind. Acad. Sci., Vol. 6A, 1937, pp. 249—256.

Sen, S. N.—

Long-range forecasting of the southwest monsoon and Everest expeditions, Sci. and Culture, Vol. 2, 1937, pp. 593—603.

Mechanism of cyclones in the Bay of Bengal, Sci. and Culture, Vol. 3, 1938, pp. 458—461.

Sreenivasaiah, B. N. and N. K. Sur—

The thermodynamics of duststorms, Curr. Sci., Vol. 6, 1937, pp. 209—212.

Sur, N. K. and K. P. Ramakrishnan—

Upper air temperatures and humidities in India during the polar year, part I, aeroplane ascents at Peshawar, Quetta, and Karachi, Beitr. Phys. Fr. Atmos., Vol. 24, 1937, pp. 199—204.

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